Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

3

Issued April 6, 1917.

HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge.

APR 12 [illegible]

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1916.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1917

Issued April 6, 1917.

HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge.

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1916.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1917

HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. True, Director of the States Relations Service, United States Department of Agriculture.]

E. W. Allen, *Chief of Office of Experiment Stations.*
Walter H. Evans, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

J. M. Westgate, *Agronomist in Charge.*
J. Edgar Higgins, *Horticulturist.*
M. O. Johnson, *Chemist.*
F. G. Krauss, *Superintendent of Extension Work.*
C. W. Carpenter, *Plant Pathologist.*
J. B. Thompson, *Assistant Agronomist, in Charge of Glenwood Substation.*
Alice R. Thompson, *Assistant Chemist.*
C. A. Sahr, *Assistant Agronomist.*
A. T. Longley, *In Charge of Cooperative Marketing Investigations.*
J. W. Love, *Executive Clerk.*

LETTER OF TRANSMITTAL.

Hawaii Agricultural Experiment Station,
Honolulu, Hawaii, July 17, 1916.

Sir: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1916.

Respectfully,

J. M. Westgate,
Agronomist in Charge.

Dr. A. C. True,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. True, *Director.*

Publication authorized.
D. F. Houston,
Secretary of Agriculture.

CONTENTS.

Page.

Summary of investigations 5
  Buildings and grounds 5
  Changes in the staff 5
  Economic collections 6
  Cooperation with military posts 6
  Algaroba investigations 7
  Horticultural investigations 8
  Chemical investigations 9
  Plant-disease investigations 10
  Agronomic investigations 10
  Extension work 11
  Glenwood substation 12
  Territorial marketing division 13
Report of the horticultural division 13
  Pineapple investigations 14
  Litchi investigations 16
  Cross-pollination of the avocado 17
  Cross-pollination of the mango 18
  Miscellaneous breeding work 19
  Miscellaneous fruits 19
  Miscellaneous plantings at Tantalus substation 20
Report of the chemical division 21
  Chemical studies of the comparative efficiency of various legumes as green manures in Hawaii 22
  Liming and soil acidity 22
  The Kauai pineapple wilt 23
  The yellowing of pineapples on manganese soil 23
  Hydrocyanic acid in cassava 24
  The edible canna 25
Report of the division of plant pathology 25
Report of the agronomy division 26
  Aquatic crops 26
  Potatoes 27
  Legumes 27
  Small grains 28
  Sorghums 29
  Grasses 30
  Nut grass control 31
  Miscellaneous crops 31
    Cotton 31
    Corn 31
    Rape 31
  Seed distribution 31

Page.
Report of the extension division 32
  General aspects of the work 32
  Extension of new crops and improved farm practices 33
  Work at the lower demonstration farm at Haiku 33
  Work at the upper demonstration farm at Haiku 35
  Extension work in connection with county fairs 36
  Maintenance of fertility of pineapple fields 36
  Organization work 38
  Collaboration in extension work 38
Report of the Glenwood substation 39
  Policies of the station 39
  Forage crops 40
  Need of a suitable hog feed 41
  Celery-disease control 42
  Poultry work 42
  Meteorological records 43
Report of the Territorial marketing division 43

ILLUSTRATIONS.

Page.
PLATE I. Fig. 1.—Pineapple seedlings in double pots. Fig. 2.—Pineapple seedlings, showing root system 16
II. Fig. 1.—Flower cluster of mango. Fig. 2.—Same flower cluster prepared for artificial pollination 16
III. Fig. 1.—Pineapples interplanted with muth beans for green manure. Fig. 2.—Dwarf Essex rape interplanted with muth beans 28
IV. Fig. 1.—Red Rustproof oats and Mexican winter rye. Fig. 2.—Johannes winter rye and Fulghum oats 28
V. Fig. 1.—Giant Bermuda grass hay. Fig. 2.—View of experimental and demonstration plats 40
VI. Fig. 1.—Celery shelter house, Glenwood substation. Fig. 2.—Consecutive eggs laid by pullets 40

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1916.

SUMMARY OF INVESTIGATIONS.

By J. M. Westgate, *Agronomist in Charge.*

BUILDINGS AND GROUNDS.

During the year the only new building erected on the station grounds was a one-room cottage for one of the laborers, whose duties necessitated his constant presence on the station grounds. A considerable number of the laborers' quarters and two of the station residences were in such condition that rather extensive repairs were considered necessary.

The grounds available for station work were materially increased by the setting aside of a 13-acre tract on the Schofield Barracks Military Reservation for use as a forage-crop experimental tract. The land available at the central station at Honolulu is not typical of much of the grass and hay land of the islands, and it is thought that the results obtained in the new location will have a wider application than would be secured were the proposed work carried out at Honolulu.

CHANGES IN THE STAFF.

The scientific staff of the station shows a number of important changes when compared with that of the preceding year. M. O. Johnson was transferred July 25, 1915, from the chemical work of the Bureau of Animal Industry, United States Department of Agriculture, to succeed W. T. McGeorge as chemist, the latter having been transferred to the Bureau of Chemistry July 8, 1915. On March 1, 1916, Miss Alice R. Thompson was transferred to the Bureau of Chemistry for a year's special work on fruits and fruit wastes. C. W. Carpenter was added to the staff as pathologist by transfer on June 1, 1915, from the Bureau of Plant Industry. J. B. Thompson was appointed assistant agronomist July 6, 1915, to become superintendent of the Glenwood substation, succeeding F. A. Clowes, who resigned on July 1, 1915, to take charge of the agricultural department of the Lahainaluna Boys' Industrial School, at Lahaina, Maui. On June 30, 1916, A. T. Longley, in charge of cooperative-marketing investigations and executive clerk of the station, was furloughed to the Territory of Hawaii so that he might devote his entire time to his duties as superintendent of the Territorial marketing division, which is carried on under the general supervision of this station. He was succeeded as executive clerk of the station by J. W. Love, who was transferred May 10, 1916, from the States Relations Service, Washington, D. C. On May 31, 1916, John McCoy resigned as collaborator. His place was filled by A. L. Arthur under an appointment becoming effective July 1, 1916.

ECONOMIC COLLECTIONS.

The numerous requests for identification of various plant diseases, fruits, grasses, legumes, and other forage and green manure crops have for some time indicated the need of a collection on the station grounds of the more important species and varieties. With this end in view a four-section herbarium case was purchased, and collections of native and introduced species of grasses and legumes, as well as of economic fungi, have been started. The fruit and other bulky specimens are being preserved in museum jars. It is planned to supplement the specimens with a file containing all available data concerning the species and varieties in question. Much of the preserved material will be available for displays at the local agricultural fairs, which constitute a new enterprise of great interest to the station.

COOPERATION WITH MILITARY POSTS.

The numerous military posts located in different parts of the island of Oahu have afforded considerable opportunity for cooperative work during the past year. The station has rendered active assistance in the efforts to establish suitable growth according to systematic planting plans for each of the military posts and reservations. Instead of cooperating with individual officers, the station has attempted, as far as possible, to have all requests for planting material come through a single representative of the Army, it being much more practicable for the station to respond to a single request for large supplies of material than to numerous requests for small amounts.

A second and more important activity from an economic standpoint has been the cooperative work in the establishment of locally grown forage grasses for feeding the Army horses and mules. A number of preliminary plantings have been made on the Schofield Barracks Military Reservation, where probably 1,000 acres of potential grass land is available for the production of such grasses and other forage crops as may be shown to be adapted to the purpose. The seeds for these plantings have been largely furnished by the station, while the actual planting operations have been conducted by the Army. During the coming year it will probably be practicable for the station to do most of the planting with its own labor.

On June 10, 1916, the station received notification from the United States Army quartermaster at Schofield Barracks that the commanding officer of the Hawaiian Department had approved the setting aside of a 13-acre tract at Schofield Barracks, and that the same had been set aside for the use of the station as an experimental tract upon which to test the best methods of growing forage for the Army horses and mules. Preliminary plantings by the Army in cooperation with this station have already been made on 9 acres of this tract. One of the handicaps under which the work is conducted at Schofield Barracks is the fact that, although there is an annual rainfall of about 35 inches, yet this occurs as torrential rains during the winter season, or in the form of light showers which do not penetrate deeply, especially if the soil is at all compact. Furthermore, the soil in question does not have normal water storage capacity.

ALGAROBA INVESTIGATIONS.

The increasing importance of the algaroba has led to the inauguration of some new lines of work which promise to develop into an important station project. There has been some discussion as to the native home of this tree which was introduced into Hawaii nearly a century ago and which has since assumed great importance as a source of firewood, honey (flowers), and cattle feed (pods). It has been claimed that it is one of the mesquites of the southwestern United States which, on being transferred to the more favorable climate of Hawaii, has developed into a large tree. A comparison with several available forms of the mesquite seems to indicate that it is a different species. In cooperation with the Bureau of Plant Industry, United States Department of Agriculture, seeds from various species of the genus Prosopis have been obtained, and as fast as these are received they are planted on the station grounds. It is expected that ultimately one or more lots of the seedlings will develop into trees comparable with the local algaroba grown under similar conditions. This will furnish a clue to the original source of the local species. It seems probable that the species is a South American one.[1]

---

[1] In a magazine entitled "Peru of To-day," an illustration, published some three years ago, was noted as picturing trees resembling very closely the local algaroba tree, while the statements regarding the character and utilization of the pods furnished further evidence that the local tree may come from the same stock as the South American species.

HORTICULTURAL INVESTIGATIONS.

The pineapple work has continued to occupy an important place in the activities of the horticultural division. The seedlings reported upon in the annual reports for 1913 and 1914 have now fruited. The showing made by the first set of seedlings was such that special efforts were made to obtain another supply of seeds, which occur so rarely in cultivated pineapples. By singular good fortune the station was able during the past year to obtain several thousand seeds through the courtesy of the management of the pineapple canneries of Libby, McNeill & Libby of Honolulu (Ltd.), the Hawaiian Pineapple Co. (Ltd.), and others. The wide variation shown in the former plantings makes it probable that the present new plantings will show some promising variations.

The work of assembling pineapple varieties from other parts of the world is progressing favorably. It is thought that there may already be in existence pineapple varieties which will prove superior in Hawaii or may be of use in cross-pollination experiments for the development of especially adapted varieties.

The work with the litchi has been mainly in developing methods of controlling the erinose disease, which is threatening some of the best trees in the islands. Considerable attention has also been given to the question of improved stocks for grafting and budding. The seeds are peculiar in that after removal from the fruit they either sprout or dry up and die within a week. This characteristic has in the past prevented the shipment of seed for long distances. Methods recently developed have been so successful that seeds have been sent as far as Florida, arriving there in excellent condition for immediate planting.

Plant-breeding work with mangoes, avocados, and papayas has been carried on during the flowering seasons of these species. The peculiar requirements of the different species have necessitated the development of a special technique in each case in order to obtain satisfactory setting of fruits. Apparent hybrids have been produced between the Chinese wood-oil nut and the Hawaiian kukui nut, it being desired to develop a hybrid the oil from the nuts of which shall be intermediate in certain characters between the oil of the parent trees, a result greatly desired by commercial dealers in drying oils.

Numerous plantings of various species of tropical plants, mostly trees, have been made during past years at the Tantalus substation, situated, at an altitude of about 1,000 feet, at the upper end of the experiment station reservation. The histories of the individual plantings are being worked up, and those completed to date have been included in this report as a matter of record.

The distributions of plant material have been largely confined to hibiscus cuttings, spineless cactus slabs, citrus seedling stocks, citrus budwood, budded seedlings of avocado and mango, and seeds of papaya. It has been decided to discontinue the distribution of plants as soon as they pass beyond the experimental stage and become suitable for commercial handling.

CHEMICAL INVESTIGATIONS.

With the recognition of the necessity for the maintenance of the humus and nitrogen content of island soils, the rôle of the various available leguminous plants becomes increasingly important. There are over a score of cultivated and wild species which are more or less efficient as green manure crops for keeping up the fertility of the soil. In order to determine which of the species are most efficient as green manures, a series of experiments has been carried out and the results submitted for publication. Those legumes should be grown the seed of which is available and which make the best growth under prevailing conditions. A number of wild legumes were found to be worthy of further test as green manure crops. It has also been found that the succeeding crop should be planted as soon as possible after the legume crop has been turned under, as the nitrate leaches rapidly from the soil and is thus lost to the new crop.

The importance of the pineapple industry has led the chemical division to devote considerable time to the pineapple problems of the islands. The "Kauai pineapple wilt" is proving most troublesome on the island of Kauai. This wilt seems to be correlated with the presence of a certain soil type, and experiments are under way to determine what treatment of such areas is most effective.

The yellowing of pineapple plants on many of the pineapple plantations on the island of Oahu was determined some years ago by this station to be due in some way to the presence of large quantities of manganese in all areas producing this effect. All the details of just how the presence of manganese induces the unhealthy condition of the plants were not worked out, however. It is believed by the present chemist that the presence of manganese so inhibits the absorption of iron by the plant that chlorosis rapidly develops. This happens in spite of the fact that the soils in question are very heavily impregnated with iron compounds, as much as 30 per cent of ferric oxid occurring at times. With the recognition that the real trouble was chlorosis, due to lack of iron in the plant itself, the standard remedy for chlorosis due to lack of iron at once suggested itself. A solution of iron sulphate was applied to the plants both as a spray and with a brush. The result was very marked, the yellow plants rapidly taking on a rich green color and the undersized, red, and stunted fruits soon becoming normal. Experiments are under way to determine the most economical iron compound to use, the number of applications necessary, the optimum strength of the solution, and other practical points arising in connection with the application of the solution on a commercial scale where thousands of acres must be treated with the greatest possible economy of time and labor.

Some studies were made regarding the hydrocyanic acid content of cassava, which is coming into some prominence as a source of starch, while the waste gives promise of value as a feed for hogs. An improved method for determining small amounts of hydrocyanic acid has been developed by the chemist during the year and an account of the method published.

An analysis of the edible canna indicated that it possesses about the same food value, pound for pound, as does the Irish potato. This work will be followed up, as the production of Irish potatoes on the islands is a most hazardous undertaking, due to the ravages of blight and related diseases.

PLANT-DISEASE INVESTIGATIONS.

The division of plant pathology was inaugurated June 1, 1916, by the transfer of the present pathologist from a similar line of work in the Bureau of Plant Industry, United States Department of Agriculture. A large part of the necessary equipment was purchased before he left Washington so that as little delay as possible would ensue in equipping the pathological laboratory for the study of the various plant diseases in the islands. A number of harmful diseases have been definitely located and studies already have been commenced concerning late blight of Irish potatoes and a leaf spot of sweet potato. Preliminary observations also have been made on the late blight of celery. Wilt of banana, taro rot, and anthracnose diseases of avocado and mango will also be investigated as rapidly as possible.

AGRONOMIC INVESTIGATIONS.

Work with such food crops as rice, taro, and potatoes has been continued largely in cooperation with commercial growers. The potato industry continues to be hampered by the diseases which seldom fail to destroy the crop. The plantings of velvet, muth, and kulthi beans have shown these crops to be especially promising as green manure plants. A promising shrub (*Crotalaria madurensis*) for use in coffee nurseries has been under test again this past year. It is able to withstand, and in fact thrives best under, considerable shade. Various clovers have been tried at the central station, but the low altitude appears to be unfavorable to their best growth. They are not to be recommended except possibly for the higher elevations, where they ought to furnish pasturage, hay, or green cut feed. Tests with small grains indicated promise for the production of grain hay, but the yields of grain thus far have not been such as to make it possible for them to compete with imported grains. The tests with the grain sorghums as a source of grain for feeding stock were much more satisfactory. A number of these sorghums are especially promising as chicken feed. At present most of the grain for feeding the numerous flocks of chickens in the islands has to be imported. In order to obtain material for crossing Japanese sugar cane with ordinary sugar cane a plat of the former is being allowed to stand indefinitely to determine whether it will flower in this latitude.

A considerable amount of work, agronomic in character, has been accomplished at the substations and demonstration farms. In most instances this work has been undertaken to solve some pressing local problem, but many of the results are of wider application, at least in a general way.

EXTENSION WORK.

Through the extension features of its work the experiment station comes into closest contact with the small farmer and his farm. The extension division has worked out several methods whereby the farmer can be made familiar with the best agricultural practices, as well as the best varieties and kinds, of crops to grow. The difficulties of travel and the remoteness and isolation of many of the farming districts naturally handicap the station in its attempts to reach such sections except at irregular and infrequent intervals. These rather infrequent visits are supplemented in a number of ways. Timely articles are written for the local press; local demonstrations are arranged on the land of the leading farmers in a given section; and attention is called to the fact that individual problems will at all times be given attention by letter and, if practicable, by a personal visit on the next trip to the section in question. Also, a number of farms are devoted primarily to the development and demonstration of the best agricultural practices for the sections in which they are located. These also serve as sources of supply for seeds and cuttings of the improved varieties constantly being distributed.

It has become increasingly evident here as elsewhere that the problems of marketing farm crops are quite as important as their production. To this end farmers' cooperative organizations have been encouraged to standardize their products, study the market requirements, and develop cooperative buying and selling to as great an extent as appears to be practicable. Remarkable interest is being manifested in the two county fairs, preparations for which have been under way for some months. The station is utilizing these opportunities to bring home to the visiting farmers many of the object lessons it wishes to teach.

GLENWOOD SUBSTATION.

The Glenwood substation, which has been carried on in cooperation with the Territory of Hawaii, was organized in part as an experiment station and in part as a demonstration of the possibilities of small farming operations under the extremely rainy conditions prevailing throughout the section in question. Some idea of the difficulties under which a farmer must work in this section may be obtained from the Weather Bureau records for the station, commencing January 1, 1916, which show only 9 clear days and a rainfall of 121.52 inches for the 6 months ending June 30, 1916. The same period shows 154 rainy days, June taking the lead with 30 rainy days. The principal work has been carried on with the dairy herd and the poultry flock. The demonstration of the importance of testing the weight as well as the number of eggs laid by an individual hen is probably the most important contribution of the station to the advance of poultry breeding. The studies on the development of feed stuffs which can be grown locally have also brought promising results. The edible canna not only promises well as a hog feed, but culinary tests with it as human food indicate that in emergencies the canna could without hardship be substituted for potatoes. It is a rapid-growing, heavy-yielding crop which might also be utilized as a commercial source of starch. The tops furnish a large amount of green forage which is eaten readily by cattle and poultry. Jerusalem artichokes have also given promising results, although they apparently must be dug only when needed on account of rapid decay after digging. Provision was made by the last Territorial legislature for necessary traveling expenses of the superintendent of the substation while on demonstration trips on the island of Hawaii. Unfortunately, no provision was made for the employment of a substitute while the superintendent was away on such trips, and the necessity of maintaining the records at the station prevented his absence from the station for more than a few hours at a time. He has, therefore, been able to do extension work on only a very few occasions, when some member of the staff of the central station was able to substitute for him at Glenwood. Considerable extension work has been done, however, members of the central station staff using the Glenwood substation as a base of operations.

TERRITORIAL MARKETING DIVISION.

The last session of the Territorial legislature made an appropriation of $12,000 a year for the running expenses of the Territorial market and $14,400 for a market building. In addition $7,500 was made available as a revolving fund for use as a working capital. The division has continued to lend its efforts to the service of the small farmer on the one hand and to the convenience of the consumer on the other. The new quarters are conveniently located and contain retail, wholesale, and storage rooms, as well as rooms for candling eggs, fumigating seeds, etc., and dressing poultry.

The need of an outlet for surplus products led to the establishment on July 1, 1915, of a marketing branch in San Francisco. This branch has been reasonably successful in handling miscellaneous shipments, but the pineapple shipments were not a success, owing to heavy spoilage and glutted markets.

More and more attention is being paid to the grading and packing of farm produce. It is not easy for the isolated producer to realize the advantage in catering to the better class of trade which demands uniform goods in uniform packages. The division is planning to provide at cost standard containers for various forms of farm produce.

Another feature of the marketing work has been the establishment of a retail department for those desiring to do their marketing in person and thus save delivery charges. The relations established with the various producers throughout the islands make it possible for the experiment station, especially through its extension division, to keep in closer touch with the farmer and his problems than might otherwise be the case. The problems of production ordinarily are quite different from those of marketing, but by cooperation between the two lines of work it is often possible to indicate improved farm practices which will result in better products for marketing purposes.

REPORT OF THE HORTICULTURAL DIVISION.

By J. E. Higgins.

The work of the horticultural division has continued along the lines of investigation that have been pursued for some years past. Few strictly new lines have been undertaken, but a number of new projects have been developed out of older ones through increasing emphasis laid upon certain phases of horticultural activity. Some investigations relating to the pineapple industry have been carried on for a long time, but there has been no opportunity for such development as the importance of the industry in Hawaii would justify. During the year just closed it has been possible to begin some work in the breeding of pineapples upon a larger scale than formerly. The litchi has also demanded increased attention. The project relating to the top-working of the mango and the avocado by bark grafting and scion budding has been closed, the final results having confirmed those recorded in the annual report for 1915. The present tendency of the work of the horticultural division is toward larger attention to plant breeding.

PINEAPPLE INVESTIGATIONS.

The work of breeding and collecting new varieties of pineapple is believed to be of considerable importance in connection with the Hawaiian pineapple industry. There are several possible methods of procedure in this matter, the first being the collection of varieties of pineapples at present in cultivation in different parts of the world. There are few varieties that have shown sufficient merit to become established as commercial sorts. It is, however, worthy of note that kinds which have not been at all successful in some pineapple-growing countries have proved remarkably successful elsewhere. The Cayenne, for example, has never found much favor in Porto Rico, where the Red Spanish has been so successfully grown, while in Hawaii the Cayenne is almost the only commercial variety. It is not improbable, therefore, that some of the little known varieties may prove to do better when introduced into Hawaii than they have done elsewhere. Attempts have therefore been made to secure as many as possible of the world's varieties, but because of the prevalence of certain diseases it has not been possible up to the present time to secure a very large number. Through the Porto Rico Agricultural Experiment Station a considerable number of the varieties grown in that island were obtained, and later one or two additional varieties were secured in Cuba and Florida. Efforts are being made to obtain a much larger collection of varieties from different parts of the Tropics.

Another method of securing new varieties is by means of the crossing of established sorts. Since none of the introduced plants have as yet flowered, it has not been possible to carry on this phase of the work except in a very limited way with pollen which has been secured through the courtesy of a local pineapple grower who had flowering plants of the variety Queen.

A still further means of securing new varieties lies in the growing of seedlings from the plants which on rare occasions produce seeds in the commercial pineapple fields in Hawaii. Four years ago a few seeds were secured and planted, and some of the resulting plants produced their first fruits in June, 1916. These seedlings have shown as wide variations as might be expected in the crossing of any two varieties of pineapples. Some are quite vigorous, while others are almost totally lacking in vigor. Some of the plants are green in color, while others from the same seed stock show a very brilliant red coloring. In some the leaves are narrow, in others broad. Some of the plants are quite as smooth as the Cayenne, while others are extremely spiny.

During the past fiscal year several thousand pineapple seeds were secured through the cooperation of a number of the pineapple canneries. It is interesting to note how rarely these seeds occur. In fact, the canneries may in some seasons run through millions of fruits without finding any seeds. During a part of the winter season of 1915–16 seeds were found with comparative frequency in fruits brought to the canneries. For example, in a run of 63,000 fruits, 9 were found with seeds. In another run of 48,000 fruits, 4 were found with seeds. It is estimated by the weight of the seed that about 2,433 seeds were obtained from these 13 fruits. With such frequency of occurrence there should be no difficulty in securing any reasonable number of seedlings, but frequent seed bearing seems to be very unusual.

Satisfactory methods have been devised for the germination of pineapple seeds and the growing of the young seedlings beyond the critical period. There are several essential conditions which must be provided, including perfect drainage, constant and uniform moisture supply, sufficient heat, and prevention of excessive growth of algæ on the surface of the seed bed. To obtain these necessary factors the following plan has been worked out: An inch or more of broken rock is placed in the bottom of the pot and above this the pot is filled to within about 1½ inches of the rim with a porous soil, on the top of which a layer of sand about a quarter of an inch thick is placed. This sand must not be of coral origin, since the lime in the coral is extremely detrimental to young pineapple plants. Molding sand, such as is used by ironworkers, has been found satisfactory. On this sand the seeds are placed, thus securing for them perfect drainage while permitting the roots of the seedlings to penetrate easily the soil beneath. The surface of the sand is covered with coconut-fiber dust mixed with a little powdered charcoal, which retards the growth of algæ and does not bake as does soil. The whole pot is then placed in a larger pot and the intervening space is packed with moistened sphagnum moss. This prevents sudden changes in moisture conditions in a climate where earthen pots dry out quickly on the sides as well as from the upper surface. Water is never applied directly to the top of the soil but when necessary the inner pots are removed and placed in water which rises to the surface. Plate I, figure 1, shows this method of starting pineapple seedlings.

A closed glass box in the greenhouse has been found to be advantageous but not essential. The close atmosphere and high temperatures aid in the early germination of the seed. Under such conditions pineapple seedlings begin to appear about 37 days after planting, while in the open, with cool winter temperature and without the close, damp atmosphere, sometimes two months or more is required for germination.

When the seedlings begin to appear some shade is necessary. Too intense light causes the plants to lose their green color and their vigor. A cheesecloth over the plants or a thin covering of whitewash on the glass of the box is sufficient, if the lights of the greenhouse have been reduced for other kinds of plants. In Plate I, figure 2, is an illustration of young seedling pineapples with the root system and the seed coat still attached.

LITCHI INVESTIGATIONS.

The investigations of the litchi (*Litchi chinensis*) have developed into an important part of the work of the horticultural division. During the year just closed attention has been given chiefly to an investigation of methods of propagation, preservation of the seeds, and preservation and shipping of the fruits. The experiments in grafting the litchi on the longan (*Euphoria longana* or *Nephelium longana*) have been continued and have proved quite successful, so far as the making of the union is concerned. The growth is very satisfactory, but it is too early to know what may be the ultimate influence of scion and stock on each other. Budding has also been tried and, although it has not succeeded so well as bark grafting, there appears to be no reason why methods should not be worked out for the budding of the litchi either on stocks of its own species or on some related species. Now that the litchi is attracting so much attention in Florida, as well as in Hawaii and elsewhere, attention should be given to the adaptability of various stocks to different conditions. Since the litchi makes a rather slow growth, stocks of more vigorous growth might be of great advantage. A more hardy species might lessen the risks from frost in the attempt to push this industry outside the Tropics. Resistance to certain pests might also be secured in this way.

The seeds of the litchi are extremely perishable, retaining their viability under ordinary conditions only two or three days. Unless they can be preserved in some way, they must be planted immediately after being taken from the fruit. As an aid in the distribution of the species, it was important to devise means for the preservation and shipping of the seeds. Experiments conducted by the station have demonstrated the possibility of preserving the seeds for

16a

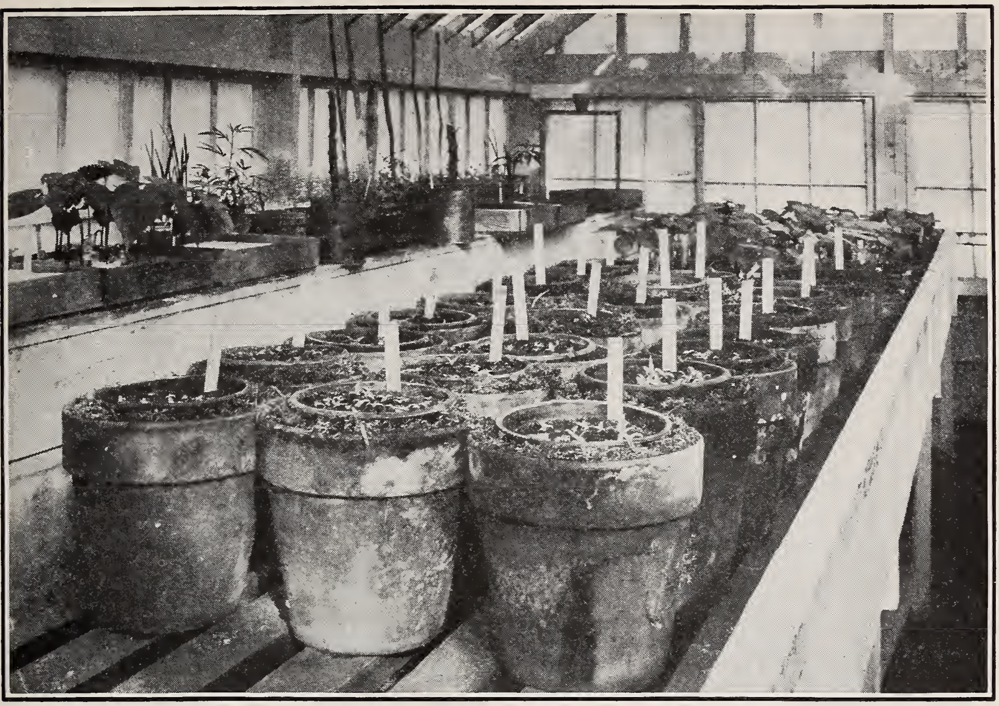

FIG. 1.—PINEAPPLE SEEDLINGS IN DOUBLE POTS.

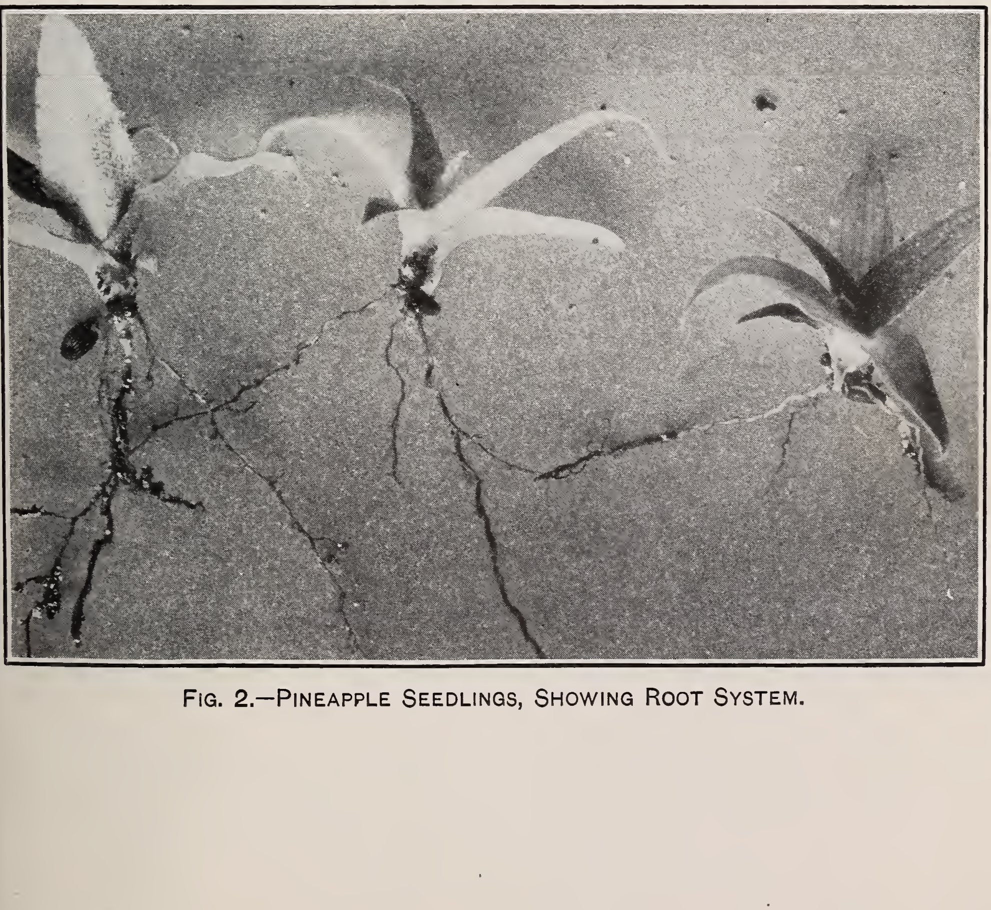

FIG. 2.—PINEAPPLE SEEDLINGS, SHOWING ROOT SYSTEM.

PLATE II.

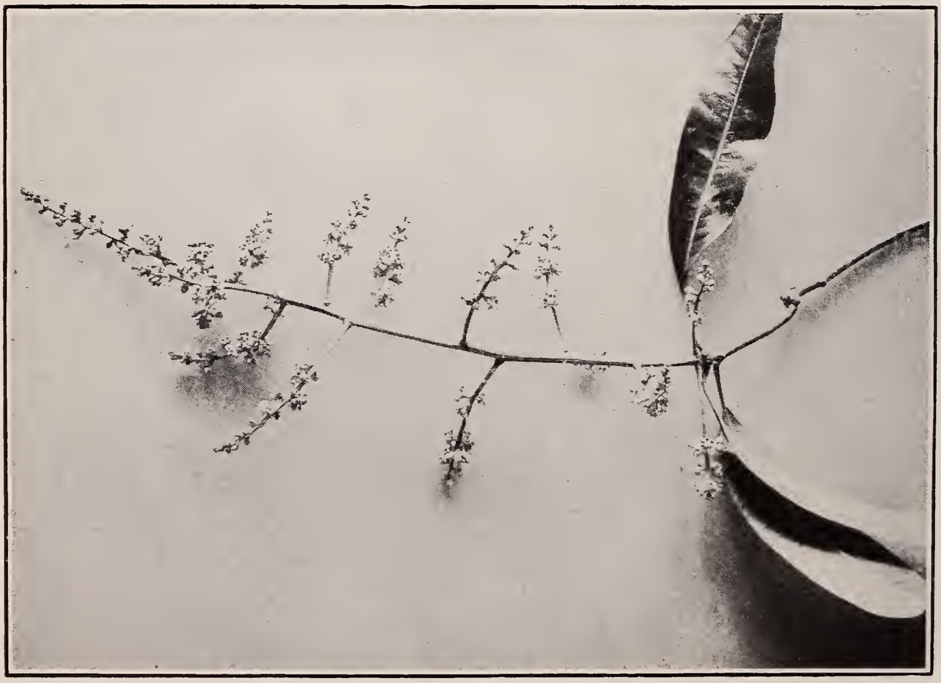

FIG. 1.—FLOWER CLUSTER OF MANGO.

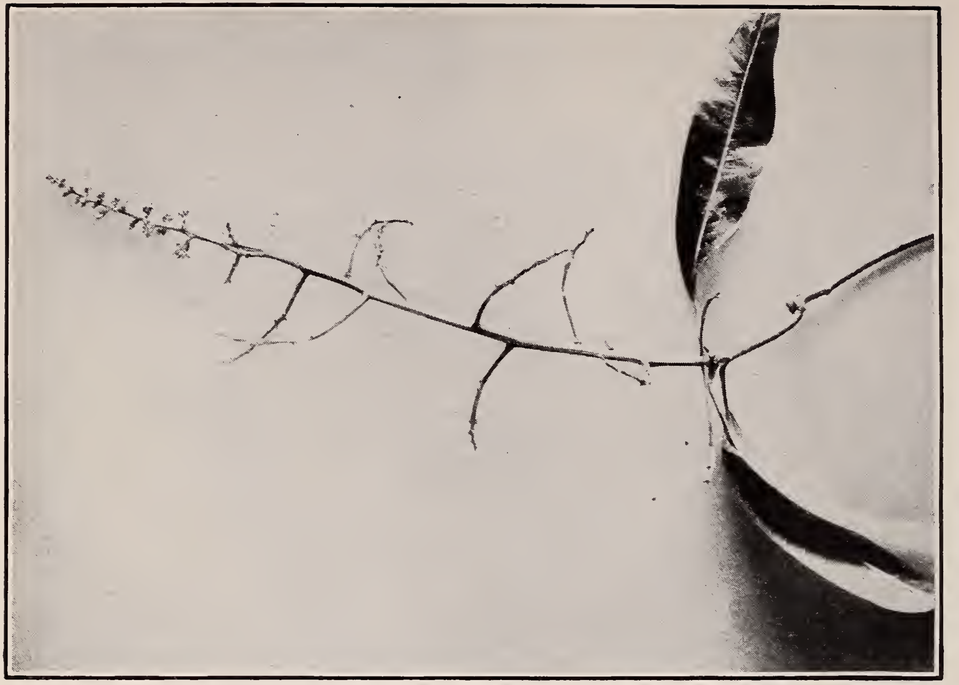

FIG. 2.—SAME FLOWER CLUSTER PREPARED FOR ARTIFICIAL POLLINATION.

several weeks and of successfully shipping them long distances by mail. Over 1,000 seeds were sent in one shipment to Florida, and were reported to have arrived in excellent condition. The method used consisted in packing perfectly fresh seeds in sphagnum moss very slightly moistened and wrapped in waxed paper surrounded by corrugated strawboard and an outer wrapper. It is important to avoid excessive moisture, as this hastens the germination of the seeds. In the shipping experiments water was added equal to half of the weight of the dry moss.

On February 3, 1916, the attention of the station was called to an apparently serious disease of the litchi. Careful investigations showed this to be due to the work of very large numbers of mites which produced galls and caused the leaves to become much distorted and covered on their under surface with a brown, woolly growth composed of trichomes, or plant hairs. Because of the similarity of this injury to the erinose disease of the grape, which is caused by another mite of the same genus, the name litchi erinose has been applied to the malady. The mite proved to be an undescribed species of Eriophyes. Experiments were undertaken immediately to determine methods for the control of the pest, and an efficient remedy has been found in spraying the tree several times with nicotin sulphate and whale-oil soap, mixed according to the following formula: Ten ounces of nicotin sulphate, 1¾ pounds of whale-oil soap, and 50 gallons of water.

Before spraying it is advisable to remove the leaves that have been most seriously injured, since these are of little use to the tree. In most cases these leaves do not represent a very large proportion of the foliage. This procedure aids in getting the mites rapidly under control, since it is difficult to make the spray enter every deep gall and penetrate the woolly covering of the leaf. If the mites are known to be present, spraying early in the season will probably keep them well in check without the necessity of removing any leaves. It is worthy of note in this connection that the longan tree, a related species, has not been found infested with this mite, although surrounded by infested litchi trees.

A survey of the city of Honolulu showed the erinose disease to be prevalent on litchi trees in several parts of Nuuanu Valley and the Kalihi district, but it was not found at Moanalua or in any other portions of the city.

CROSS-POLLINATION OF THE AVOCADO.

Owing to the illness of V. S. Holt, assistant horticulturist, during the season when the avocados were in flower, progress was somewhat delayed on this project. Prior to Mr. Holt's return to the work, James Cowan devoted some time to this project. Studies have been made of the flower, the maturation of pollen, and the technique of hand pollination, including emasculation and thinning the flowers. The proper thinning of flowers was found to be a very important factor in success, as improper thinning causes many of the hand-pollinated flowers to fall. It was not easy at first to effect cross-fertilizations, but before the end of the season a considerable number of apparent crosses were made successfully.

CROSS-POLLINATION OF THE MANGO.

The location of this work for the present year was shifted from the station experimental orchards to Moanalua Gardens, near Honolulu, because of the total failure of the station trees to flower this season after the heavy crop of July and August, 1915. Through the courtesy of the management of the Moanalua Gardens, it was possible to carry on the work there but under greater difficulties because of the distance from the station and the necessity of frequently visiting the trees before and after pollination.

The first phase of the work was the determination of a suitable technique for the pollination of the mango, and the second, the origination if possible of new varieties combining desirable characters now found in different varieties, as, for example, the high color of the Scott with the flavor and texture of the Pirie. It is felt that much has been accomplished in relation to the development of an efficient technique in so far as the results can be judged by the setting of the fruits, a considerable number of which were nearly mature June 30, 1916, being apparently the result of cross-pollination. These crosses include the varieties Scott, Pirie, Kavasji-Patel (Cowasjee-Patel), Alphonse, Paheri, Java, and a new unnamed sort.

On the mango there may be several hundred flowers in a single cluster which is able to mature only a few fruits (Pl. II, fig. 1). In cross-pollinating, it is necessary to select a few of the best flowers and to cut out the others to prevent their setting fruit. This makes it possible to segregate the selected flowers and protect them from chance fecundation by covering the cluster with a paper bag. Frequently the best flowers are found on the very short branchings near the outer end of the central axis. When such is the case, the flowers are removed from the larger side branches (see Pl. II, fig. 2), but these side branches must not themselves be cut off or the whole cluster may fail. The flowers at the end of the cluster are not disturbed. In carrying on this pollination work, flowers are prepared the day before transfer of pollen is made. After the flowers have been emasculated and any others that might pollinate them have been removed, the whole cluster is covered with a large paper bag which must be removed for pollination and be replaced immediately. Later flowers on the cluster may be operated upon in the same manner.

MISCELLANEOUS BREEDING WORK.

The work in papaya breeding has proceeded along the lines indicated in earlier reports and in a bulletin of the station.[1] There are at the present time no specially important developments to be recorded. A number of new plantings have been made from seeds collected from the cross-pollination of different forms and some of these plants are now coming into fruit. The chief work at the present time includes the hand-pollinating of elongata forms for the purpose of securing a strain which will produce this type of fruit with the greatest possible uniformity, the crossing of certain forms to secure further data relating to the determination of sex and the combining of desired characters.

The 72 seedlings, believed to have resulted from the attempted hybridization of the Chinese wood-oil nut (*Aleurites fordii*) with the Hawaiian kukui nut (*A. moluccana*) and referred to in the annual report for 1915, have been transplanted to the Tantalus substation where both of the parent species succeed better than at the lower altitudes. The seedlings rather closely resemble the female parent in most cases, but present some noticeable variations which are thought to be due to hybridization.

MISCELLANEOUS FRUITS.

The general variety and cultural tests with tropical and subtropical fruits have been continued, including the establishing of plantings of a large number of species and varieties as a basis for any further experimental work which it may seem advisable to undertake. The citrus orchards at the central station are in better condition than they have been for some years past, owing in part to favorable weather conditions with frequent rains which have relieved the difficulty arising from shortage of water. Another factor which contributes to the present condition of the orchards is the better control of insect pests than in the earlier years. The Mediterranean fruit fly, however, continues to be a serious pest in case of oranges and grapefruit, limes being less injured than these and lemons suffering least of all the citrus fruits. The Villa Franca and the Eureka lemons have borne heavily in the main orchards, and on Tantalus, at an elevation of about 1,000 feet, where a few trees of Genoa lemons have been planted, the results are very satisfactory. It would seem that a larger proportion of the lemons consumed in Hawaii might be grown here.

---

[1] Hawaii Sta. Bul. 32 (1914).

The mango crop for the summer of 1916 in the station orchards is almost a complete failure, as is the case with mangoes in most parts of Honolulu. This is probably due in part to the continuous heavy rains during the flowering season and also in part to the very heavy crop during the summer of 1915. It is probable that a severe thinning of the fruits in the early part of 1915 would have resulted in a finer quality of fruit in 1915 and an increase in production in 1916.

The avocado orchard, which is on rather heavy soil underlaid in places by rock, suffered from the excessive rains during the winter season, but the trees which escaped this injury set a fair crop in 1916.

Feijoa sellowiana has made two attempts at fruiting, one during the past year, but has failed to bring fruit to maturity. This new fruit, commonly known as the pineapple-guava or feijoa, is now attracting much attention among the growers of subtropical fruits in California and Florida. It is indigenous to western Paraguay, southern Brazil, Uruguay, and Argentina, where its fruits are highly esteemed. The fruit has the appearance of a small guava and somewhat resembles the pineapple in flavor. These characteristics have given rise to the name pineapple-guava. The two trees in the station collection have made good growth and appear to be in a thiriving condition, but both have been slow in coming into bearing, and, as stated above, neither has yet matured a crop, although the larger of the two was well loaded with fruits which grew to about three-quarters the normal size before falling.

Some experiments in grape culture have been undertaken on a cooperative basis with a grower at Wahiawa on the island of Oahu. The vines planted are of the Hawaiian strain of the Isabella variety which has given best results in these islands. If other varieties are grown they will be grafted on these stocks. The experiments have included the trial of different methods of preparation of the soil, the use of fertilizers, and the control of the Japanese beetle (*Adoretus umbrosus*). Other experiments may be developed as the vineyard progresses.

Preparations have been made by F. G. Krauss at the Haiku substation for planting several acres of gulch land to the more important tropical and subtropical fruits, as avocados, mangoes, oranges, limes, lemons, grapefruit, grapes, etc.

MISCELLANEOUS PLANTINGS AT TANTALUS SUBSTATION.

For over 20 years miscellaneous plantings have been made in the vicinity of what is now the Tantalus substation. Some of the early plantings were made before the establishment of the experiment station and have continued under observation until the present time.

From time to time since the establishment of this experiment station, miscellaneous plantings have been made, mostly of material which was thought to require an elevation higher than that of the central station in Honolulu, which is only a little over 100 feet above sea level. Most of the plantings were tree stock, which requires a rather long period for maturity. It was thought, however, that for purposes of record the available notes of previous years and the current notes should be assembled and published. The notes on a number of species are appended.

Two loquat trees (*Eriobotrya japonica*) were planted in January, 1907. The trees were secured from the California Nursery Co., Niles, Cal., and were of the Giant and Victor varieties. The trees have made healthy and vigorous growth and have borne regularly for several years. The fruit of the variety Giant is large, bright orange in color, and is produced in large clusters. The flavor is considered very good and the fruit is considered adapted for use in sauces, jellies, preserves, pies, etc., as well as for eating uncooked. The fruit of the Victor is smaller and lighter in color. When eaten fresh the flavor is said to resemble somewhat that of cherries. The tree is more vigorous and a heavier cropper than the Giant.

Two lots of camphor trees (*Cinnamomum camphora*) have been under observation, one planted in 1894, the other in 1908. The older trees are much larger than the later plantings and are sufficiently developed for a test of their camphor content. The trees of the later planting were from 8 to 12 feet in height on April 15, 1916, with a spread of 6 to 7 feet. The trees appear healthy, vigorous, and without insect or fungus pests. They are of the variety which yields the Formosan camphor. No attempt has been made to determine the commercial value of these trees for Hawaiian conditions.

A small group of trees of *Macadamia ternifolia* is growing at the substation, the trees having been planted shortly prior to 1893. The trees are vigorous, considering their crowded condition, and some bear fruit quite regularly, indicating their value if properly cultivated and fertilized. The nut, which is known as Australian nut, is rich, highly flavored, and contains more than 66 per cent fat. The composition of the nut is given in the report of the station for 1914. The most serious obstacle to the commercial importance of this nut is its extremely hard shell.

REPORT OF THE CHEMICAL DIVISION.

By Maxwell O. Johnson.

During the past year the work of the chemical department has been mainly on problems of soil research, especially those of pineapple soils. The project on legumes as green manures was completed and the project on the acidity of Hawaiian soils continued with some modifications as compared with previous years. The hydrocyanic acid in cassava roots was determined by a new method devised in this laboratory for the determination of this acid in very small amounts. Such soil, fertilizer, feed, and other analyses in connection with the general work of the station as were possible with the reduced staff were performed during the year.

CHEMICAL STUDIES OF THE COMPARATIVE EFFICIENCY OF VARIOUS LEGUMES AS GREEN MANURES IN HAWAII.

During the past fiscal year Miss Alice R. Thompson, assistant chemist, completed the pot experiments comparing the relative efficiency of the various legumes as green manure crops and the results have been submitted for publication. These experiments were described in the annual report for 1915.

Twenty-two varieties of legumes were grown on two Hawaiian soils of different types. Three crops were matured, using four pots for each trial of each variety. The plants were removed at maturity and weighed and the amount of nitrogen in them determined. The nitrogen was determined in the soils before planting and after removing the crop, and it was shown that the soils had lost no nitrogen and had usually made a slight gain, owing probably to decayed roots and nodules. The amounts of nitrogen contained in the various legumes were thus clearly gained by bacterial assimilation of atmospheric nitrogen. When, however, the plants were turned under with the soil and allowed to weather for several weeks, leaching of the rapidly formed nitrates took place, and when the soil was analyzed the gain in nitrogen in many cases was less than it should have been according to the amount of nitrogen turned under. This is of interest, as in most previous experiments with legumes the gain in nitrogen has been calculated by an analysis of the soil after a crop of legumes has been turned under. It is thought that the first method (that of determining the nitrogen in the crop removed and showing that the soil has suffered no loss in nitrogen, or deducting the loss if there should be any) gives results by which the legumes can be better compared with other nitrogenous fertilizers, as these fertilizers also suffer loss by leaching in the soil. These results would indicate that unless a planting is made soon after turning under a green manure crop there may be a considerable loss of quickly available nitrogen.

LIMING AND SOIL ACIDITY.

It is remarkable that, in spite of the great excess of bases found by analysis in Hawaiian soils, many of these soils should show a high degree of acidity when tested by the Veitch and other methods. In view of this fact and the increasing evidence of the benefits of liming in the States, a thorough investigation is being made of the character of the acidity of Hawaiian soils and the effects of lime on their properties. Large quantities of soils from three different islands (Hawaii, Oahu, and Kauai) have been secured, and the results of tests with these, it is hoped, will be of fairly general application in the islands. On the assumption that in whatever form lime is applied the carbonate and bicarbonate will result, an investigation is being made of the reaction of Hawaiian soils to calcium bicarbonate under various conditions, and the results promise to be of considerable value.

THE KAUAI PINEAPPLE WILT.

The "Kauai wilt" of pineapples is a very serious trouble, affecting the success of many homesteaders on the island of Kauai, especially in the Kapaa district. As preliminary tests of soil samples secured from this section in connection with a general field trip by the chemist showed a very small amount of lime in the soil, with a high degree of acidity, and about half as much lime in the ash of the wilting plants as in that of the healthy ones, it was therefore thought that acidity might have some connection with the wilt. A special trip was made to the pineapple district of Kauai and a large number of soil samples secured. As one result of the analyses made, a successful correlation was worked out between the wilt and the light-yellow soils, which have been derived from lavas acted upon by steam and sulphuric acid vapor near centers of former lateral crater activity. The acidity of the samples collected corresponded closely with the field notes on the wilt. Pot and field experiments with different forms and amounts of lime are being made to determine the effect of liming.

THE YELLOWING OF PINEAPPLES ON MANGANESE SOIL.

Considerable areas in the Wahiawa, Kunia, and other pineapple districts of the island of Oahu contain large amounts of manganese. The pineapple plants on these black manganese soils are affected very seriously, turning yellow and producing little fruit, which is of inferior quality. These manganese soils and their effect on the pineapple plant have been investigated thoroughly by this station in former years and the results published.[1] In these publications the yellowing is attributed to some indirect action of the manganese in the soil, as "a modification in the osmotic absorption of lime and magnesia." Up to the beginning of 1916 the only treatment that has been at all successful has been the application of large quantities of stable manure. This method, however, is very expensive, and the supply of available manure is limited.

---

[1] Hawaii Sta. Buls. 26 (1912) and 28 (1912), Press Bul. 23.

It appeared to the present chemist of the station that the pineapple plants were suffering from an insufficient supply of iron, a small amount of which is considered necessary for the proper functioning of the chlorophyll. Field trials confirmed this hypothesis, since yellow and dying plants brushed with a solution of iron sulphate rapidly became green and healthy and began a vigorous growth, which has continued up to the present time (June 30, 1916). Numerous field experiments have been made on large areas of yellow plants which were sprayed with a solution of iron sulphate and in every case the treatment has proved successful. The best conditions for application, the most suitable strength of solution, the optimum number of sprayings, etc., are being worked out, but already it is apparent that this treatment will be very profitable to the growers, as excellent crops are ripening on manganese soil on which approximately $2.50 an acre for four sprayings has been spent.

HYDROCYANIC ACID IN CASSAVA.

The roots of the cassava or manioc (*Manihot utilissima*) contain the very poisonous hydrocyanic acid (prussic acid). Owing to the increasing cultivation of this plant in Hawaii for the preparation of starch and as a cattle and hog feed, determinations of this hydrocyanic acid were made. Previous methods for the determination of small quantities of this acid proving unsatisfactory the chemist devised a convenient and accurate method, which has since been published.[1] Some determinations of the hydrocyanic acid in cassava are of interest. Unfortunately, the varieties used could not be classified except under their vague common names of "bitter" and "sweet."

Hydrocyanic acid content of cassava.

No.	Kind.	Source.	Age.	Character of soil.	Diameter of root.	Part of plants.	Hydrocyanic acid.
			Mos.		*Inches.*		*Per ct.*
1	Sweet	Station	18	Poor heavy clay	1	Whole roots	0.006
2–A	do	do	6	Good light clay.	¾	do	.025
2–B	do	do	6	do	¾	Peel of roots	.042
2–C	do	do	6	do	¾	Peeled roots	.021
3–A	Bitter	do	6	do	¾	Whole roots	.008
3–B	do	do	6	do	¾	Peel of roots	.015
3–C	do	do	6	do	¾	Peeled roots	.007
4–A	do	do	24	do	5	Whole roots	.013
4–B	do	do	24	do	5	Peel of roots	.025
4–C	do	do	24	do	5	Peeled roots	.007
5	Sweet yellow	Waialua, Oahu		do	1½	Whole roots	.006
6	Bitter	Kauai	9	do	1	do	.014
7	do					Waste (from whole roots used for starch manufacture).	.003
8	do					Waste (from peeled roots used for starch manufacture).	.0008

---

[1] Jour. Amer. Chem. Soc., 38 (1916), No. 6, pp. 1230–1235.

From the results obtained it would appear that cassava waste is perfectly safe for use as a hog feed, if, as is usually the case, it is boiled before feeding. Moore[1] estimates 0.008 per cent or more of hydrocyanic acid as dangerous in feeding the fresh root. The chemical division would caution against the use of cassava for feed unless the finely divided roots are thoroughly boiled with two or three changes of water.

THE EDIBLE CANNA.

The edible canna (*Canna edulis*), known also as the "Queensland arrowroot" and "tous-les-mois," appears to be well suited to Hawaiian conditions. Analyses were made of samples submitted by J. B. Thompson, superintendent of the Glenwood substation, Hawaii. Two sizes of canna rootstocks were analyzed. No. 1 refers to the small rootstocks about 2 inches long and No. 2 to rootstocks 5 or 6 inches in length. The results are figured on both the fresh and the water-free basis. The results given for the fresh rootstocks are most interesting. They show little difference in the ash, fiber, fat, and protein for the small and large rootstocks, but a remarkable increase in the nitrogen-free extract in the larger rootstocks. The following table gives the results of the analyses:

Analysis of the edible canna.

Constituent.	Fresh basis.		Water-free basis.	
	No. 1.	No. 2.	No. 1.	No. 2.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Water	81.58	65.86	....	....
Total solids	18.42	34.14	100	100
Ash	.81	.81	4.39	2.37
Crude fiber	.54	.64	2.93	1.88
Fat (ether extract)	.13	.15	.71	.44
Protein	1.37	1.20	7.45	3.52
Nitrogen-free extract (starch, sugar, gums)	15.57	31.34	84.52	91.79

REPORT OF THE DIVISION OF PLANT PATHOLOGY.

By C. W. Carpenter.

The division of plant pathology of the station was established June 1, 1916, with the transfer of the present pathologist from the Bureau of Plant Industry, United States Department of Agriculture. Previous to June 1, the investigations of diseases of plants at this station had been limited to such studies as could be made by the members of the staff incidentally along with their regular lines of work. It had become more and more evident, however, that the diseases of the economic plants of the islands demanded more adequate attention than had been given them.

---

[1] U. S. Dept. Agr., Bur. Chem. Bul. 106 (1907), p. 16.

The pathological laboratory has been fairly well equipped and is being brought into working order as rapidly as possible. Arrangements have been made for the installation of an herbarium case in which pathological specimens will be deposited as they become available by collection and exchange.

The most important diseases at present calling for attention are late blight of Irish potato, late blight of celery, anthracnose of avocado and mango, taro rot, and banana and pineapple wilt. Other plant diseases have been observed as follows: Leaf spot and fruit rot of papaya; leaf spot, stem blight, and fruit rot of guava; leaf blight and pod blight of Lima bean and string bean; common scab of Irish potato and also a wilt disease of this host which has been confused with Phytophthora blight; and cabbage soft rot. Leaf injuries probably of fungus origin have been noted on the following hosts: Lemon, orange, fig, peach, poha, coffee, carrot, sorghum, loquat, Java plum, corn, rutabaga, sweet potato, and pineapple. Knotting and dwarfing of young corn plants appear to be serious in certain localities. Specimens of stem blight of mammee apple (*Mammea americana*) similar to that on guava have been collected.

REPORT OF THE AGRONOMY DIVISION.

By C. A. Sahr.

During the year new projects on cassava and fiber plants were inaugurated. The project on cassava includes test of varieties for the production of forage and starch, the determination of best cultural methods, and a study of methods for the utilization of cassava waste. The project on fiber investigations has for its object the determination of yield and quality of different fiber plants, especially sisal (*Agave sisalana*) and sunn hemp (*Crotalaria juncea*).

AQUATIC CROPS.

The work with rice and taro in the vicinity of Waiau, Oahu, is progressing favorably. Checks have been made upon average yields obtained from the 1915 spring and fall crops from the plat designed to serve for the test of aeration of soil for rice. Owing to excessive rains and high winds the 1916 spring crop of the nonaerated plat fell 51 per cent below the yield of the same in 1915. In the aeration soil test for the spring crop of 1916 the nonaerated plat outyielded the aeration plat by 18.7 per cent, the increase favoring nonaeration being 490 pounds of rice paddy.

The test of aeration of soil for taro was begun in the middle of August, 1915. The fertilizer test with taro was inaugurated at the same time, and it was expected that the plats would be harvested during the first week in July, 1916. Further work with aquatic crops has been commenced in cooperation with Jonathan Aiau at Waialua.

POTATOES.

The work with potatoes for the year at the central station was limited to the planting of three varieties to obtain material for pathological investigations. The manured portion of the plat was divided into three sections for further tests with Bordeaux mixture and lime sulphur spray for the control of fungus diseases. In a variety test at the Tantalus substation (elevation 1,000 feet), the Early Rose outyielded the Burbank and the American Wonder. In a culinary test of these varieties, the Burbank, although exceeded in size by the American Wonder and the Early Rose, proved superior in mealiness and flavor.

LEGUMES.

Four new varieties of velvet beans were received from the Office of Forage Crop Investigations, United States Department of Agriculture, during April, 1915, and were grown in the variety test plats with one variety from Porto Rico (supposed to be *Stizolobium capitatum*) and seven varieties under test by this station for several years. The stands obtained from the four new varieties were too uneven for reliable yield data. Sufficient seed was obtained for a second planting.

Another legume of unusual promise as a green manure or forage crop has been found in the muth bean (*Phaseolus aconitifolius*), seed of which was received from the Bureau of Plant Industry. As with kulthi (*Dolichos biflorus*) the water requirement of the muth bean is much lower than that of most other leguminous forage crops. The growth is at first erect but soon becomes prostrate, forming a dense mat upon the soil. Calculations from trial cuttings of muth bean grown between rows of pineapples represent average yields of about 15 tons green matter per acre for a four months' period of growth. (See Pl. III, fig. 1.)

Crotalaria candicans (S. P. I. No. 28606), of which mention under the name *C. madurensis* was made in the annual report of this division for 1915, has given considerable promise as a leguminous shrub for shading in coffee nurseries. Although somewhat checked by drought and aphis attacks in the summer of 1915, the plants failed to show material effect of damage from either of these sources of injury.

With the early fall rains considerable damage from scale was noted on the main stems and lower branches. This trouble was effectively treated with a proprietary oil spray especially prepared for the San José scale. The plants came to full bloom during January, 1916, the pods maturing in early March. A plat 8 by 8 feet having 11 plants produced 3½ pounds of seed.

Trials with *Desmodium hirtum* for several years failed to produce results of consequence. Growing the plants in shade was suggested, and a further trial was made on a plat prepared not 10 feet away from the trunk of a flourishing young algaroba tree. The growth made by the shaded plat of this legume during a period of 6 months is nearly equal to that made by another plat in the open during 15 months.

Of the true clovers (*Trifolium pratense*) planted in the forage plant garden February 27, 1915, cuttings of the red clover plats were made on January 5, 1916. The average yields of green forage for these clovers are as follows: Red clover from Switzerland (S. P. I. No. 37939), 8.55 tons; ordinary red clover (F. C. I. No. 1472), 8.45 tons; Swiss Rummellee clover or apitrefle (S. P. I. No. 37937), 2.1 tons; and red clover from Switzerland (S. P. I. No. 37938), 1.8 tons.

The clover plants have flourished in the past season of unusual coolness and humidity during the spring of 1916, and the next cutting will be made for seed in the latter part of July, 1916. A cutting of the alsike clover made January 20, 1916, represents a yield of 6.15 tons per acre. Further cutting of this stand also awaits proper maturation of seed. Of the white clovers, ordinary white (S. P. I. No. 34930) made appreciably more growth than did wild white (S. P. I. No. 38579) and Ladino white (F. C. I. No. 1482). A stand produced from *Trifolium striatum* (F. C. I. No. 1450) succumbed to drought in the summer of 1915, while *T. dubium*, replanted on April 17, 1915, produced a good stand and was maturing seed in July, 1916.

SMALL GRAINS.

A test of small grains for yields of grain and forage was begun December 15, the experiment including five varieties of winter rye, two varieties of oats, and one variety of winter barley. As in previous tests the ryes made the best growth at the start, but to date only the Mexican winter rye (Pl. IV, fig. 1) has headed out, and the stand is so sparse as to indicate exceedingly unsatisfactory yields of both grain and forage. The oats stands of both the manured and check plats were harvested June 5, Fulghum yielding 70.75 pounds forage and 2 pounds 13½ ounces grain for the manured plat and 59 pounds forage and 2 pounds 5½ ounces grain for the check plat (Pl. IV, fig. 2) while Red Rustproof yielded 112.5 pounds forage and 2

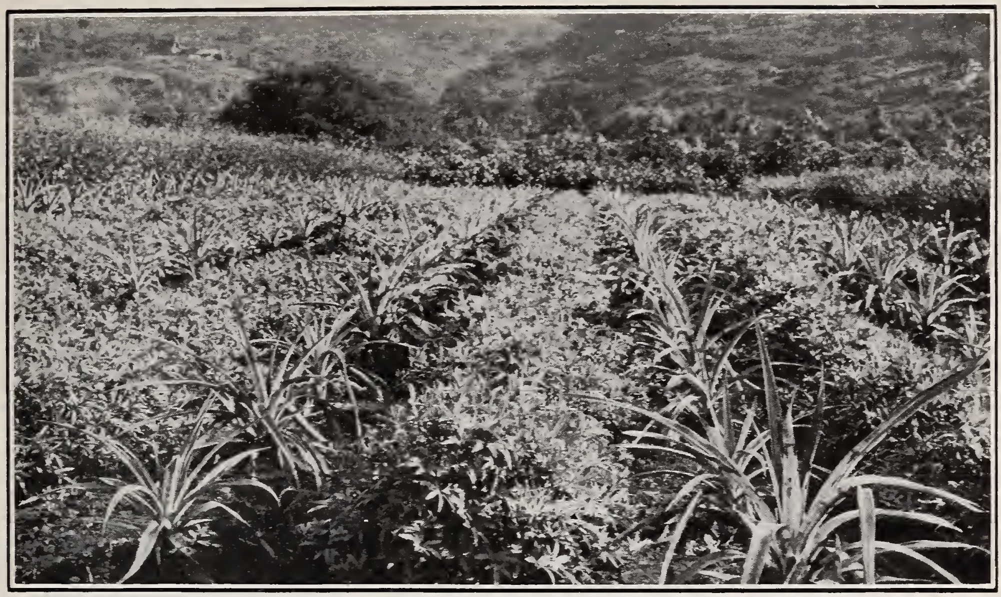

FIG. 1.—PINEAPPLES INTERPLANTED WITH MUTH BEANS FOR GREEN MANURE.

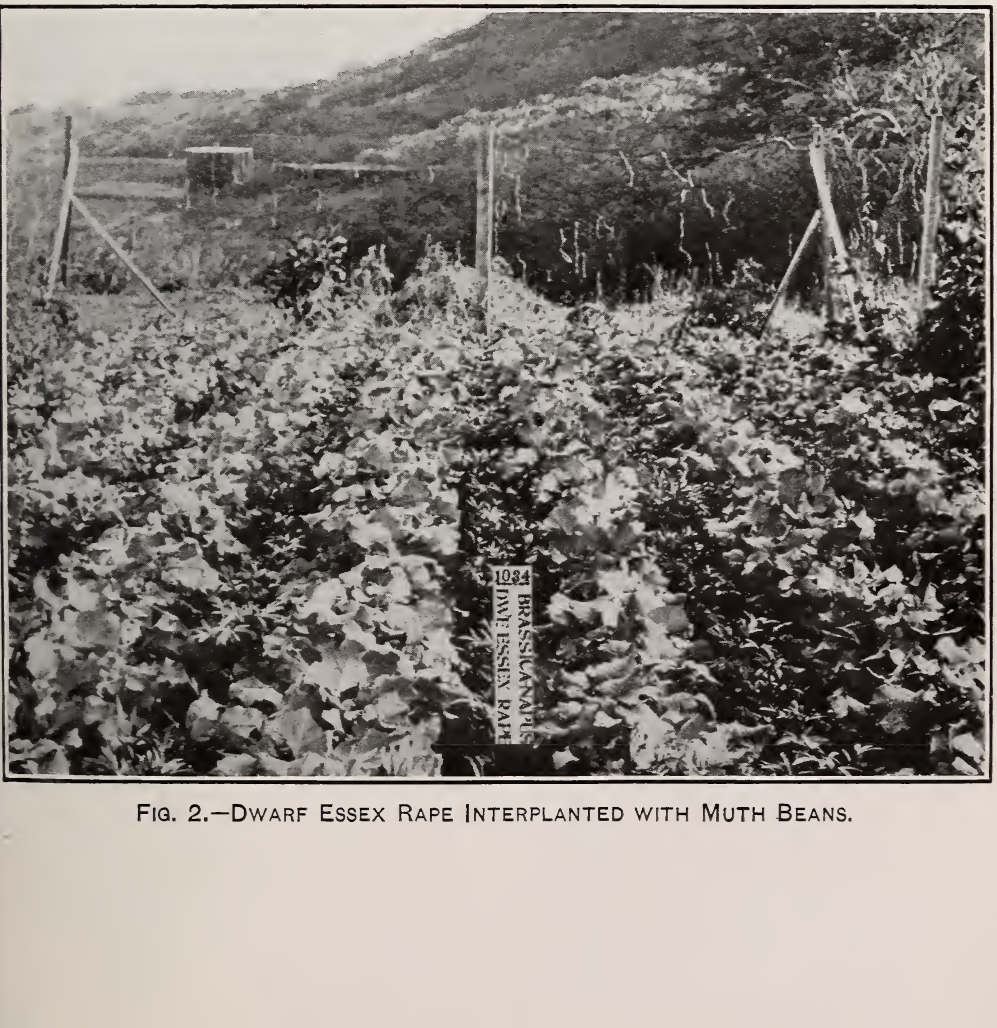

FIG. 2.—DWARF ESSEX RAPE INTERPLANTED WITH MUTH BEANS.

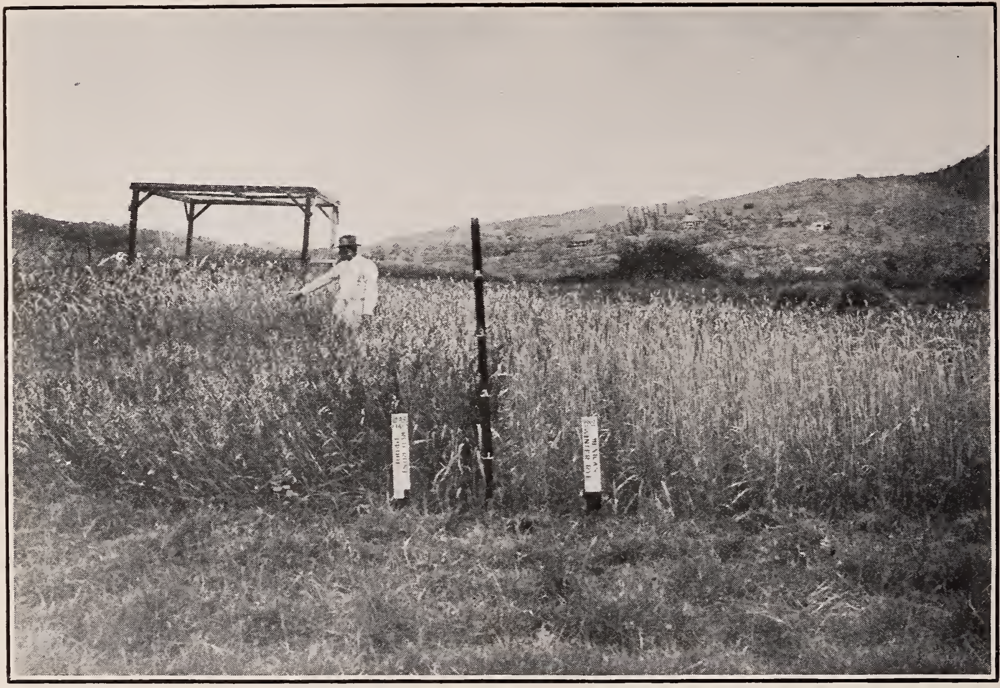

FIG. 1.—RED RUSTPROOF OATS (LEFT) AND MEXICAN WINTER RYE (RIGHT).

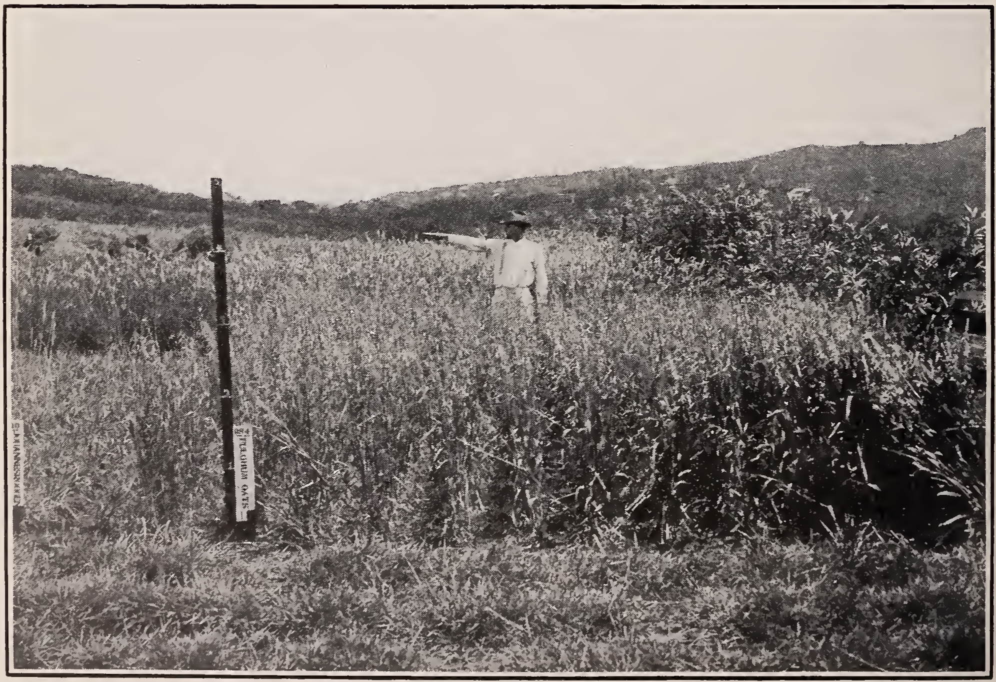

FIG. 2.—JOHANNES WINTER RYE (LEFT) AND FULGHUM OATS (RIGHT).

pounds 5½ ounces grain for the manured plat, and 94 pounds forage and 3 pounds 13 ounces grain for the check plat (Pl. IV, fig. 1), indicating yields of from 13 to 22 bushels of grain per acre. The stand of winter barley has failed to head out to date.

A second planting, including five varieties each of oats, barley, and rye, and three varieties of wheat, was made March 28. Of the oats, Fulghum, Swedish Select, and Sixty Day had headed out to some extent on June 5, Fulghum taking the lead. Of the barley, only the Smyrna variety had headed out by June 5. A yellow wilted area across the center of the barley plats was found upon examination to be due to an attack of aphis. Owing to the moist and cool conditions prevailing during the spring the ryes and wheats, with the exception of the winter varieties, are expected to produce good results. Duplicates of the cereal tests described above are being made at Waimea, Hawaii, and at Makawao and Haiku, Maui, the tests in the first two districts named being made at an altitude ranging from 2,500 to 3,200 feet.

SORGHUMS.

Owing to the very limited area on which corn can be profitably raised in the Territory, attention has been given to the production of grain sorghums to supplement corn. The results of a test for yields of grain and forage with kafir corn, milo maize, and feterita in comparison with Sugar Drip sorghum, sown April 19, 1915, are given below:

Results of a comparative test with sorghums.

Type of sorghum.	Date of harvest.	Plat yields.		Acre yields.		Number of days to mature.
		Forage.	Grain.	Forage.	Grain.	
		Pounds.	*Pounds.*	*Tons.*	*Pounds.*	
Kafir corn	Aug. 5	993	5½	6	66.5	107
Milo maize	Aug. 2	748	36¼	4.52	436	104
Feterita	do	1,100	19⅛	6.65	235	104
Sugar Drip	Aug. 5	1,863	57	11.27	689	107

The low yields of grain and forage from kafir corn substantiate the statement made in the 1915 annual report that yields from this crop are very adversely affected by drought. It should be stated here, however, that the extremely low yields of grain recorded for the kafir corn in the above test are also due to harvesting before the stand obtained uniform maturity, about 10 days more being required with kafir corn than with Sugar Drip sorghum.

In the 1916 test of grain sorghum, Manchu kaoliang, dwarf milo, and dwarf kafir have been added to the number included in the 1915 test. These were sown April 15 under the most equable conditions obtainable. The first heads were noticeable in the Manchu kaoliang stand on June 1, in the feterita on June 3, and in the milo maize on June 7. The fact that kafir corn, milo maize, and kaoliang have been listed under grains in the San Francisco and Los Angeles Produce Exchange for some time past suggests the importance of the production of these crops in Hawaii, since heavy importations of grains are at present necessary.

A new long-period test for yields of forage was begun in August, 1915, and excellent stands of nonsaccharin sorghum No. 309 and of Japanese cane were obtained, the plantings being made July 17 in field N, west of the administration building. The plat of No. 309 sorghum consists of 33 rows 4 feet apart, each row containing 36 plants 2 feet apart in the row. The stand of Japanese cane was planted in 26 rows, 77 feet long and 5 feet apart, of which 13 were propagated by division of roots and the remaining half by cuttings of the canes. The stand was cut for the first time for yield of forage December 29, the estimated acre yield of the stand produced from cuttings totaling 2 tons more than the yield of the stand produced by division of roots.

GRASSES.

Cuttings of two new grasses, Napier grass (*Pennisetum purpureum*) and Cayenne grass (S. P. I. No. 38946), were received from the Bureau of Plant Industry December 24 and planted on December 29. A good stand of Napier grass was obtained, but only a single plant of Cayenne grass. The first-named produced flourishing heads throughout April, but owing to ravages by birds no seed was obtained. A large assortment of grass seeds containing a few varieties previously introduced was also received from the Bureau of Plant Industry in April, and is being held for planting when the autumn rains commence.

Demonstration plats, each 96 by 19½ feet, were planted in field N to Wilder grass (*Andropogon nodosum*), Australian blue grass (*A. sericeus*), fuzzy top (*A. saccharoides*), Natal redtop (*Tricholæna rosea*), and a triangular plat, 97 by 56 by 113 feet, was sown to Giant Bermuda grass. (See Pl. V, fig. 1.) These grass plats represent the five best drought-resistant pasture grasses for low and medium elevations. (See Pl. V, fig. 2.)

Of the grass plats in the grass garden planted in the fall of 1913, Mitchell grass (*Astrebla triticoides*), side oats grama (*Bouteloua curtipendula*), tall fescue (*Festuca elatior*), American buffalo grass (*Bulbilis dactyloides*), *Bromus unioloides*, *B. erectus*, *Paspalum notatum*, *P. nodosum*, and *P. virgatum* have continued to thrive, although severly checked during seasons of drought. Other grasses sown at the same time and sharing the same conditions of growth, while unthrifty, still persist in their original plats. Of these, a single plat of meadow foxtail (*Alopecurus pratensis*) produced heads in May, and *Paspalum compressum* bloomed in April. Slender wheat grass (*Agropyron tenerum*), *Phalaris bulbosa*, *Poa arachnifera*, and *Bromus sericeus* furnished considerable herbage, but so far have failed to bloom.

NUT GRASS CONTROL.

As in the previous years, work on control of Japanese nut grass has proved that spraying with arsenite of soda is the most effective means of control if the spray is applied when the grass is in full bloom. Plowing with a disk plow is effective if done at intervals of four or five weeks during exceedingly dry periods. Quantities of tubers found on the surface of the soil following effective plowing and raked together after weathering for four weeks, when again planted in boxes, failed to start new growth after a reasonable period.

MISCELLANEOUS CROPS.

Cotton.—Representative stands of Egyptian, Sea Island, Columbia (upland), and Caravonica "wool" cotton have been maintained for demonstration purposes and to supply select seed of each variety.

Corn.—A repetition of the 1914 fertilizer and rotation test with Reid's Yellow Dent corn was commenced in November, 1915. The mechanical condition and moisture content of soil during the life of the stand were favorable, but after five weeks of growth the stand was materially affected by the leaf hopper (*Peregrinus maidis*), the yield of grain being so reduced as to furnish no reliable data.

Rape.—Tests with rape in previous years have generally been failures owing to the loss of the crop through drought and aphis attacks. A stand of Dwarf Essex rape obtained from a planting made May 1 is shown in Plate III, figure 2, made 32 days after sowing. The second rows on each side of the stake, cut for estimating the approximate yields of forage per acre, averaged about 11 tons produced in 50 days.

SEED DISTRIBUTION.

As in previous years the demand for seed by farmers and homesteaders has been large, chiefly for seed of pasture grasses and soiling crops. Numerous requests for cuttings of forage grasses which do not produce seed readily were filled by the division. Among these should be mentioned especially the Giant Bermuda grass, which is proving very promising for pasture and hay.

REPORT OF THE EXTENSION DIVISION.

By F. G. Krauss.

GENERAL ASPECTS OF THE WORK.

The extension division during the past year has given increased attention to the purely extension phases of the work. The writer has made seven official trips during the year, all the principal islands having been visited and numerous cooperative connections established. Nearly all the members of the entire scientific staff of the experiment station have made one or more trips to the various islands where it was possible for them to give valuable assistance along extension lines in connection with their principal lines of inquiry and investigation. Much of the extension work with farmers has necessarily been done through correspondence, nearly 800 letters having been received and answered during the year, in addition to at least an equal number handled at the experiment station at Honolulu. Fully 200 persons have visited and inspected the central demonstration farm on Maui during the past year. About 20 meetings of farmers have been attended by the station staff where part was taken in speaking and in discussions. A number of prominent agriculturists and educators have been invited to address farmers' assemblages held under the auspices of the extension division.

In addition to extension work, the division has given considerable attention to two related phases of the work. The extraordinarily wide diversity in soil, rainfall, and exposure to winds makes it impossible to lay down hard and fast rules regarding the details of the best agricultural practices upon a given farm in any particular section of the islands. Two localities well within sight of each other may require an entirely different set of crops and cropping systems. This condition of affairs calls for the working out of the best practices in each particular locality. This is being accomplished by means of cooperative field tests of different methods of crop production and demonstrations on the farms of the best farmers available and also on specially equipped demonstration farms, five of which have been established in different parts of the islands under the direct management of the extension division.

The second related phase of extension work to which attention has been given has been the organization of the farmers for their mutual benefit for business and social purposes, and especially for marketing to best advantage the products of their farms. This branch of the work, although but recently instituted, already has resulted in the organization of several important farmers' associations which have assisted in developing new markets for farm produce as well as in helping to start several new and promising cooperative agricultural enterprises which, it is believed, will prove of material benefit to the small farmer. E. C. Moore has had immediate charge of carrying out this work of organization.

EXTENSION OF NEW CROPS AND IMPROVED FARM PRACTICES.

Probably the work of most direct benefit to the farmers at large under the present status of the development of diversified agriculture in these islands is the introduction and extension of new crops or improved varieties of established crops and the actual demonstration of improved farm practices. This division has undertaken to establish in various parts of the islands demonstration farms under its immediate control and cooperative experiments with farmers on their own farms. The object has been "teaching by doing" things which hitherto have been merely written and talked about. The demonstration farms at Haiku have had under cultivation during the past year some 60 acres in miscellaneous crops. These crops, the experiment station at Honolulu and the experimental plantings at Haiku have demonstrated, are promising for culture on a commercial scale.

WORK AT THE LOWER DEMONSTRATION FARM AT HAIKU.

This is the principal demonstration farm on the island of Maui. It is situated on the lower and drier section of the homestead tract located in Kuiaha, Pauwela, and Kaupakulua. The farm is typical of an extensive area of potential farming land now devoted to grazing. The units selected for the demonstration work appear well suited to the purpose. While it is at present held in private ownership, it has been suggested that the county of Maui take the land over and make it into a permanent institution. The value of the work undertaken is directly proportionate to the length of time over which such work extends. Cropping systems, based on crop rotation and green-manuring practices, can not demonstrate their value unless carried on over a long period. This can only be assured by State or county ownership.

Thirty-five acres is at present under crops on this farm. Both virgin land and previously cropped land are this year under test to demonstrate their comparative fertility. Careful cost accounts are being kept to determine the comparative expense of clearing land by various methods, such as hand grubbing, blasting, and power clearing. Various "methods of tillage" experiments in connection with the production of the different crops are under way.

The entire area was planted in the spring of 1916 to three established varieties of field corn developed in breeding plats maintained by the writer for several years as a private enterprise. The entire area of corn is being intercropped, as the result of extensive experiments conducted by the writer for a number of years. These crops include the following legumes: Cowpeas, sunn hemp, soy beans, velvet beans, culinary beans (several varieties), sweet potatoes, Irish potatoes, peanuts, and other seed crops for feeding and green-manuring purposes. All are being grown in sufficient quantity to demonstrate their commercial value and also to provide means for obtaining practical figures as to costs of production. Not the least important work at this farm is the working out of satisfactory methods of storage, grading, and marketing of these comparatively new crops.

In addition to the above crops, a large number of comparative tests are being made of new crops to show their adaptability to the prevailing conditions. These crops at present include 18 varieties of cereals, which are being grown in cooperation with the agronomy division of the experiment station, some 40 varieties of grain sorghums and millets, and 10 varieties of root crops, mostly for stock and poultry feeding experiments to be conducted later. Many of these crops are being tested at the direct request of farmers in the neighborhood and throughout the islands.

All the crops at the lower demonstration farm are being grown both with and without fertilizers and with and without green-manuring crops to demonstrate the feasibility of these several practices under existing conditions. Already it has been demonstrated that high-grade fertilizers can be made to double the yield of Irish potatoes, while with field corn the commercial fertilizers have given comparatively little increase. Heavy green manuring, however, more than doubled the yield of corn. Likewise, the crops of corn on virgin soil in this particular locality are fully twice as heavy as on the land previously cropped to corn. From this it would appear that Hawaiian soils generally are lacking in humus, and plans are being made to test this theory in connection with subsequent crops.

An important phase of the cultural work being undertaken at this farm is the selection and improvement of pure strains of farm seeds especially adapted to local conditions. Begun as a private enterprise by the writer in 1912, the work to date has resulted in the establishment of a superior strain of Yellow Dent corn, two superior varieties of Irish potatoes, two new varieties of sweet potatoes, as well as a number of new legumes for green-manuring and stock-feeding purposes.

In the general distribution of seeds and plants inaugurated by this division during the past year there were distributed 6,450 sweet potato cuttings (2 varieties), 825 Irish potato eyes (2 varieties), 150 pounds field corn (3 varieties), 660 root divisions of grasses, 20 pounds grass seed, 87 pounds beans (culinary), and 100 pounds leguminous seeds (for stock-feeding and green-manuring purposes).

A number of the above crops had already become established in the immediate community from a previous limited distribution. Among the most prominent of these is Sudan grass, which in 1913 was represented by a 100-foot test row. It may be safely said that at present at least 100 acres is devoted to this valuable hay and soiling grass in the Haiku district alone. In addition to the stocks indicated above which have been sent out upon request, large quantities have been delivered to persons calling at the farm. In all these distributions the recipients have been requested to report upon the results of their trials. It is believed that such data accumulated from a wide area will in time prove of great value in establishing crop zones.

WORK AT THE UPPER DEMONSTRATION FARM AT HAIKU.

At the upper or central demonstration farm at Haiku, Maui, which constitutes the headquarters of the extension division, the principal lines of work have been with pineapples. A considerable amount of general experimental work supplementing the investigations of the station at Honolulu is being undertaken. A meteorological station, which includes temperature, precipitation, and wind velocity observations, was established in January, 1916, in cooperation with the Weather Bureau. It is planned to extend this phase of the work considerably for the purpose of further correlating crop production with climate, a new line of work recently inaugurated by the United States Weather Bureau at Washington. About 15 acres at this station is now devoted to pineapple experiments and demonstrations. Experiments are now under way in tillage, planting, fertilizing, green manuring, drainage, and determining the relative merits of various types of plants. Five acres are devoted to a cropping and feeding project which has for its purpose the restoration of worn-out pineapple lands, the most important problem which now confronts pineapple growers in Hawaii. Five acres constitute a trial ground for the testing of new crops, seed of which has been furnished largely by the station at Honolulu. At the present time more than 100 grasses, clovers, and other economic crops are being grown in comparative tests. In cooperation with the horticultural division of the station, an experimental fruit-growing project has been developed for the purpose of determining the adaptability of the protected gulch lands for the culture of grapes, citrus, and other tropical fruits. An acre and a half of land has already been cleared and a portion is now being terraced to determine the value of this method of preparing steep hillsides for the cultivation of fruits and other crops. These experiments were undertaken by the station because of the belief on the part of settlers that these heretofore waste lands sheltered from the prevailing heavy winds might be developed into highly productive and profitable areas.

The growing demand for choice home-grown vegetables has led to a series of successive plantings of a large number of the more popular vegetables in order to determine the best season for the different varieties.

EXTENSION WORK IN CONNECTION WITH COUNTY FAIRS.

The extension division has taken the lead in the inauguration of the first Maui County agricultural fair, to be held in November, 1916. Great enthusiasm for it is being shown in every quarter. The sugar plantations and pineapple plantations are cooperating heartily with the so-called small farmer in furthering the common interests of the community. There is every indication that this fair will prove of great value to all concerned, not only for its direct practical value in showing what can be grown, but in bringing the community to a realization of the value of cooperation. This division, through the Glenwood substation on Hawaii, is taking an active part in the furtherance of the second Hawaii County fair, the first fair having proved very successful last year. It is hoped that the county fair idea will spread to each of the other islands and finally result in a great Territorial fair in which all of the counties shall participate.

MAINTENANCE OF FERTILITY OF PINEAPPLE FIELDS.

In the last annual report stress was laid upon the projects planned with a view to working out some rational system of soil management whereby the worn-out pineapple lands could be renovated. The solution of this problem becomes more and more important as the best pineapple areas become used up, as is fast being done. It is as yet too early to predict which of the several methods now being tested will prove most effective in the maintenance of satisfactory yields of pineapples.

The extensive cooperative experiments undertaken with the Haiku Fruit & Packing Co., at Haiku, in which the accumulative renovating power of green-manuring legumes is being tested over a period of five years, is progressing favorably in that the several green-manuring crops planted last fall grew well and were plowed under in the spring of 1916, according to schedule. The same area was again replanted with the exception of the one unit reserved for planting to pineapples. After the entire area has been successively replanted to pineapples and the subsequent crops harvested and weighed valuable data will become available. The experiment and demonstration, however, will not be completed until 1923. This fact is mentioned to indicate the length of time required to conduct an experiment of this nature. Much credit is due the cooperating company for its willingness to undertake an experiment running for so many years.

Another project with the same object was planned with a view to making the land bring in tangible returns during the entire period given over to renovation by leguminous crops. This, it is hoped, will be accomplished by feeding off the crops grown on the land. The resultant gains will contribute to the support of this line of work, which was put into effect in January, 1916. In advance of the report on the completed experiment the preliminary data and estimates are given below in the hope that they may prove suggestive to those interested.

The area under experiment was planted to pineapples in October, 1912. The first crop, averaging 22.5 tons per acre, was harvested between January and November, 1914. The second (first ratoon) crop was harvested during the latter half of 1915, and yielded at the rate of 21 tons per acre. The third (second ratoon) crop (on the divisions still in pineapples) is just beginning to mature. The yield, owing in part to the unfavorable season, will probably fall below 10 tons per acre. The entire area was paddocked off into four equal subdivisions. The first paddock was pastured to four head of mules and one cow per acre during January, February, and March, 1916, and with an average of 10 hogs during April, May, and June, 1916. The area under pasture was covered with a rank growth of weeds and grass as is usual at the end of a cropping period during which weeding has been suspended for a considerable time. The live stock showed preference for the young fruits and buds and even the young leaves of the pineapple plants over the grass and weeds which would ordinarily be classed as fairly good pasturage. At the end of six months the entire herbage excepting the old pineapple stumps had been eaten off, so that the hogs had to be given a small supplementary feeding of sweet potato tops to finish out the six-months period. If an allowance is made at current rate for pasturage of cattle, the land would yield a revenue of $13.80 per acre per annum, without taking account of the remaining half of the year. Much of the value of the organic matter produced on the land is, of course, retained either in the form of stubble or manure, and this is the main object sought. However, the project as now planned calls for the shifting of the stock to the next area as soon as the other section is fed off, while the pastured-off area is immediately plowed and cropped to one of several green-manuring summer legumes. If the season is moist it is planned to plant to field corn intercropped with a legume, which, for the present purpose, is preferably the cowpea or velvet bean, either of which makes excellent feed for growing hogs, especially when supplemented with corn. These crops may, of course, be either pastured off or harvested, cured, and fed separately. From work previously done at the central Haiku farm, where the present project is under way, it is fair to assume that a ton of shelled corn and leguminous seeds can be produced per crop per acre, and that two such crops can be grown per annum. If these estimates are realized in the present project, it will be seen that enough grain should be grown per acre during the last half of the present year to produce from 300 to 400 pounds of pork, live weight, allowing 5 to 6 pounds of grain per pound, live weight. This, with the corn stover and pea vines, will go far toward making the renovation period at least self-supporting.

ORGANIZATION WORK.

One important phase of the extension work has been that of helping the farmers to help themselves through properly organized activities. E. C. Moore, of Haiku, has had immediate charge of this line of extension work of the division. A statute covering the organization of cooperative societies was passed at the last session of the Territorial legislature. A number of cooperative societies have been formed, and the extension division has endeavored to keep in close touch with all the cooperative activities of these organizations and to render all possible assistance to them.

It has been found that the problem of the necessary bookkeeping usually gives considerable difficulty to a newly formed organization of this nature. The immediate object of most of the cooperative organizations has been the more profitable production and marketing of the special crops. The Territorial marketing division, with which the extension division is cooperating, ordinarily handles individual consignments of miscellaneous farm produce, but more closely organized effort is regarded as necessary in connection with the production and marketing of such special crops as pineapples, sugar cane, bananas, and algaroba beans. Some assistance has been rendered various groups of farmers in connection with contracts with the pineapple canneries and the sugar mills for the disposal of their products. During the year a mailing list of farmers has been prepared for the use of the extension division.

COLLABORATION IN EXTENSION WORK.

In order to reach as many farmers as possible on the outlying islands, three farmer collaborators have been engaged to devote a part of their time to the extension work. These are in homesteading sections and on the farm of the best available farmer, and while the collaborator continues to operate his own farm, he also conducts demonstrations in crop production to serve as object lessons to the other farmers of that section. Another duty of the collaborator is to render all possible assistance to the neighboring farmers in the establishment of better markets for their crops and in the development of standard grades of production to meet the demands of the best buyers. The collaborator on Kauai, J. de C. Jerves, has been instrumental in spreading the Madeira sweet potato throughout the islands, where it has proved of exceptional merit.

The collaborator at Hilo, Hawaii, J. E. Gamalielson, has been very active and painstaking in the marketing of dairy and poultry products for the homesteaders in that district. At Kamuela, Hawaii, Mr. John McCoy and his successor, A. L. Arthur, have undertaken demonstrations in the production of crops which can be fed to live stock and thus marketed. The preliminary efforts in raising perishable products in this section were shown to be unprofitable, owing to the distance from markets for such produce and to the lack of suitable transportation facilities.

The extension work of the Glenwood substation at Glenwood, Hawaii, is under the general supervision of the extension division.

REPORT OF THE GLENWOOD SUBSTATION.

By J. B. Thompson.

POLICIES OF THE STATION.

The work of the Glenwood substation has been planned, during the past fiscal year, to conform to the necessary policy of economy enforced by a 50 per cent cut in the Territorial appropriations for this station. The activities have, therefore, been confined to lines of work requiring little financial outlay or capable of being conducted on a self-supporting basis. The labor force has been reduced to a single workman, most of whose time has been occupied in the performance of daily routine work involved in the care of the live stock. All operating expenses have been reduced to a minimum and the work has been planned with a view to using the returns for continuing the investigations. With funds available for only one laborer and with the numerous daily records required in connection with the trap-nest tests in the poultry pens, the necessity of keeping the climatological records up to date, as well as the numerous duties incumbent upon the superintendent of an experiment station, it has been out of the question for the superintendent to be away from the station on demonstration and extension work for more than a few hours at a time. It is hoped that arrangements may be made during the ensuing year for members of the staff of the central station to substitute for the superintendent at Glenwood and thus enable him to keep in closer touch with the farmers in the outlying portions of the island.

FORAGE CROPS.

One of the most seriously felt wants of the Glenwood dairy farmer is that of a good, nutritious, milk-producing forage crop that can be successfully grown on the farm, one that will not only satisfy the appetite, as do honohono (*Commelina nudiflora*) and Para grass (*Panicum barbinode*), used extensively under the present system of feeding, but also tend to increase the milk flow and replace a portion of the expensive concentrated ration now being used. Both honohono and Para grass make indifferent growth during the colder season of the year, and a habit of strong winter growth would specially enhance the value of such a feed. Australian water, or Paspalum, grass (*Paspalum dilatatum*) has given greatest promise among the grasses under test at the substation, and it is being planted to a limited extent on some of the local dairy farms. The persistent habits of growth of this species and its natural tenacity of life might, however, render its eradication difficult under existing conditions of continued rainfall. The relation of this grass to forage poisoning of stock in the Southern States as reported upon by Brown and Ranck[1] also suggest a possible source of danger from its general exploitation in Hawaii. The authors of the above-mentioned bulletin advance what appears to be conclusive evidence in support of the theory that certain cases of stock poisoning were due to pasturing on Paspalum grass and find the direct cause in an ergotlike fungus which attacks this grass, existing as a parasite on its pistillate flowers. In view of the serious nature of this malady, it would seem that the live stock interests of Hawaii should be safeguarded by effective and rigorous precautionary measures regulating the importation of Paspalum seed. The possibility that other widely distributed local species of this genus, such as the common Hilo grass (*P. conjugatum*), might also serve as a host plant for this fungus would further emphasize the importance of preventing its introduction.

A few volunteer plants of California bur clover were found to be growing on the substation grounds in December, 1915, and their development during the comparatively cold months from December to April was observed with interest. These plants took possession of a garden plat after it had been thoroughly spaded on December 6, 1915, and made rank and rapid growth until removed on April 11, when the plat was cleared for planting to other crops. The supposition that the seed from which these plants grew was introduced through the medium of imported hay and probably lay in the ground for several months before germinating, combined with the fact that a very heavy crop of seed was nearing maturity when the

---

[1] Mississippi Sta. Tech. Bul. 6 (1915).

PLATE V.

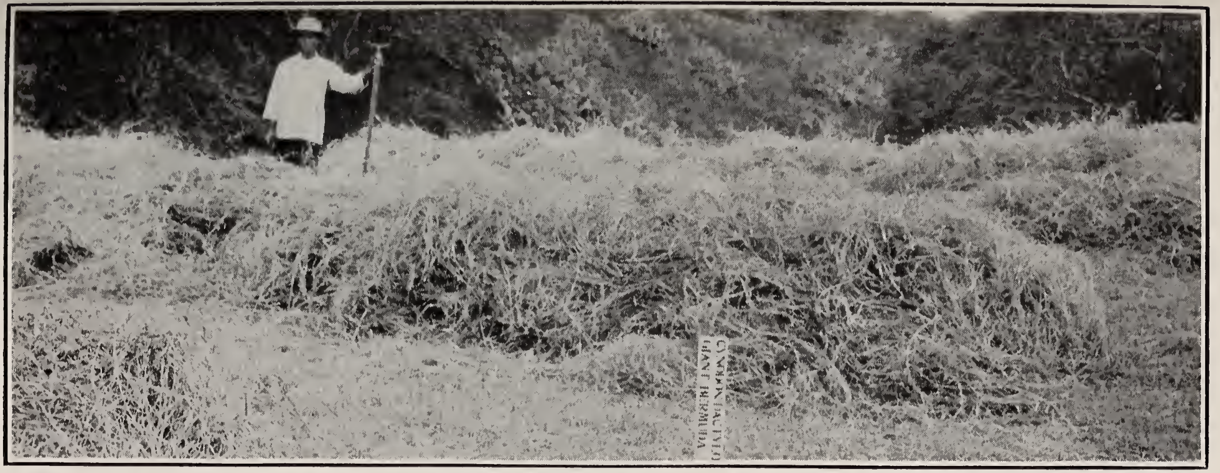

FIG. 1.—GIANT BERMUDA GRASS HAY.

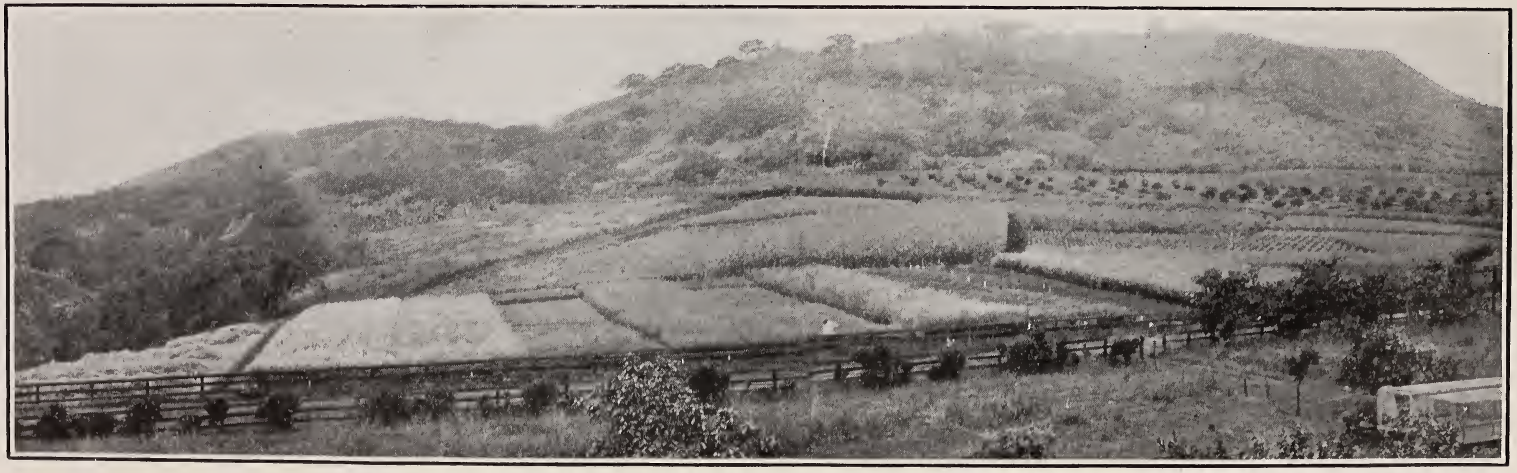

FIG. 2.—VIEW OF EXPERIMENTAL AND DEMONSTRATION PLATS.

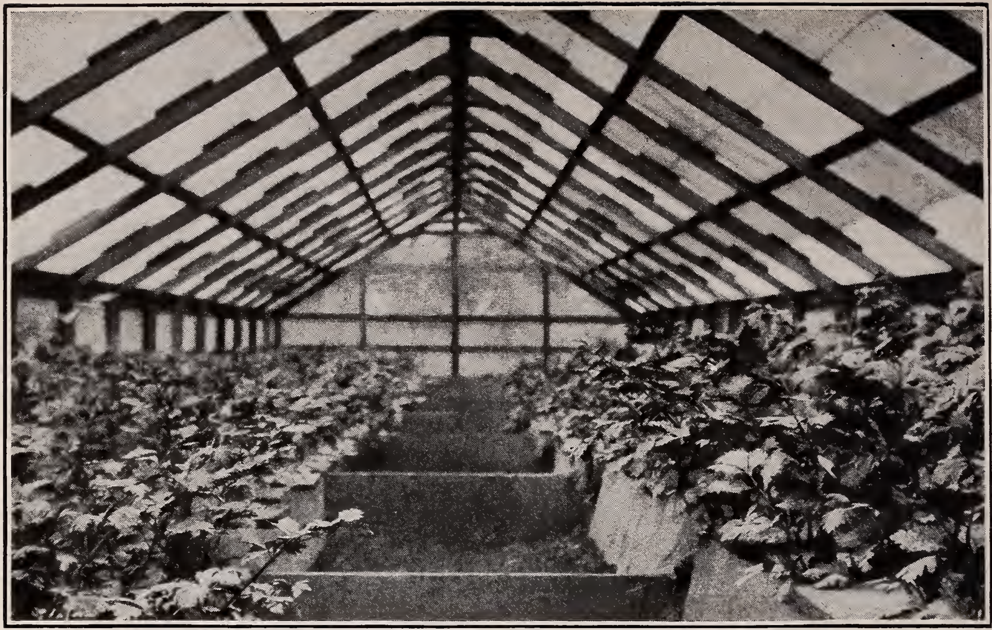

FIG. 1.—CELERY SHELTER HOUSE, GLENWOOD SUBSTATION.

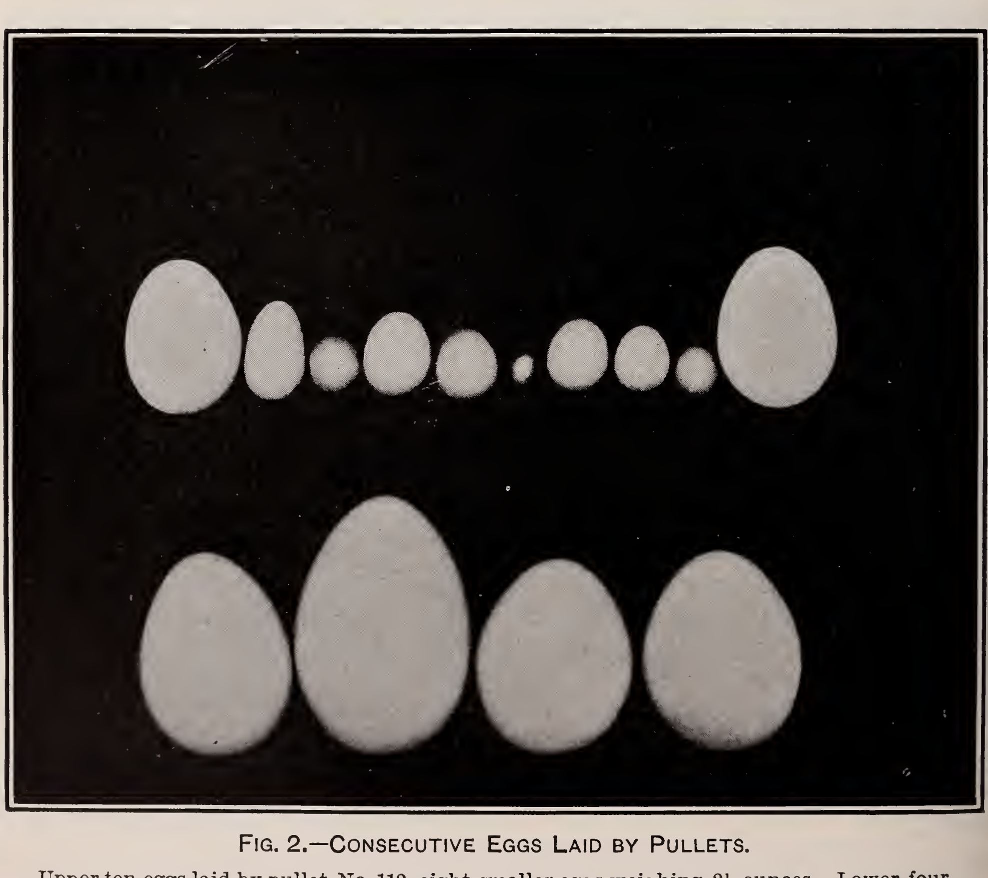

FIG. 2.—CONSECUTIVE EGGS LAID BY PULLETS.

Upper ten eggs laid by pullet No. 112, eight smaller eggs weighing 2¼ ounces. Lower four eggs laid by pullet No. 172.

plants were destroyed, leads to the hope that California bur clover will reseed itself under climatic conditions that obtain in this district. A supply of this seed has been ordered and trial plantings will be made during the coming winter season.

NEED OF A SUITABLE HOG FEED.

In the Glenwood district, where practically the entire homestead population is largely dependent upon the sale of dairy products for a livelihood, a keen interest is shown in the problems of hog production, this industry being a natural adjunct of the dairy, where an excess of skim milk is available in varying quantities throughout the year. A strong deterrent, however, to this alluring feature is the high price of supplementary feed and the lack of any suitable grain crop that is known to be profitable for local production. The substation, in its work for the past few years, has given attention to the problem of supplying a satisfactory feed that will constitute a dependable crop under local farm conditions.

On December 10, 1914, a planting of the edible canna (*Canna edulis*) was made on a measured area of 575 square feet. This was harvested on January 14, 1916, yielding a total of 833 pounds, or at the rate of 31.5 tons per acre. The crop was grown on a plat of good garden soil and the yield was probably considerably greater than would have resulted from plantings made under average field conditions. Another trial was begun on the same plat on January 25, 1916, and on April 5, 1916, a field planting was completed on soil of rather low fertility and without the use of fertilizer. A portion of the product dug on January 14 and kept stored at the substation in ordinary bags for a period of three months showed practically no loss from decay, thus indicating the ease and simplicity with which it can probably be handled in a damp, rainy climate where much loss might be expected. Samples of the fleshy rhizomes of the canna, submitted to the station chemist, showed a composition closely comparable to that of the Irish potato.

In this quest for a local product for hog feed a trial planting of Jerusalem artichokes (*Helianthus tuberosus*) was made during the preceding fiscal year on an area of 960 square feet. This crop was dug on November 5, 1915, yielding a total weight of 490 pounds, or, figured in terms of acre yield, a fraction more than 11 tons. A large portion of this planting failed to grow and the stand was estimated at 33⅓ per cent at the time of harvest. Unlike the edible canna, the Jersusalem artichoke has not kept well in storage, being attacked by a moldlike fungus and completely ruined when stored in bags. In working over the garden plat upon which this crop was grown, a number of roots were found on January 25 in a perfect state of preservation. These were planted immediately and showed no growth until the first week in May, when a portion of them was found to be sprouting. These observations would suggest the necessity of digging the crop as needed for feed or of allowing the hogs to dig them at will. For general purposes, delayed harvest or a system of stratification would seem to be necessary.

CELERY-DISEASE CONTROL.

By referring to the tabulated meteorological data at the end of this report (p. 43), it will be recognized that marketable money-making crops that will succeed under conditions at Glenwood and its surrounding territory are decidedly limited. The very high precipitation is an unfavorable element, but the low night temperatures constitute an even more decisive factor in the limitations of general crop production. There are few cash-returning crops that thrive under these peculiar climatic conditions. Celery is a notable exception to this rule. There is a constant demand for celery of good quality, and this is being very inadequately met, most of the limited supply being of foreign origin. The one serious problem involved in the production of celery here seems to be the prevalence of late blight, caused by the fungus *Septoria petroselini apii*, and as long as this disease can be controlled, celery grows with unsurpassed luxuriance. The heavy rainfall and the frequency of rainy days preclude efforts to control this disease on unprotected plantings by the usual methods of spraying. During the past year the substation has inaugurated a line of experimental tests in which an effort is being made to produce the crop under shelter, a frame building (see Pl. VI, fig. 1) 72 by 16 feet and covered with cheesecloth having been constructed for these trials. This work has included the disinfection of seed with a weak formalin solution before sowing and the spraying of plants in the usual manner with Bordeaux mixture prepared in accordance with the 5:5:50 formula. At the time of this writing the progress of these trials is encouraging, but maximum efficiency would require complete overhead protection in the construction of which a sufficient amount of glass should be employed to insure an optimum of sunlight.

POULTRY WORK.

The poultry-breeding work being conducted at the substation with the object of increasing both the average number and the average size of eggs through selective breeding has been of unusual interest (Pl. VI, fig. 2). Complete trap-nest and individual egg-weight records have been kept throughout the year. The past season's hatch consists of 212 birds, including both sexes, ranging from two to less than five months old at the time of this writing. The pullets from the first hatch are just beginning to lay. The greater number of these birds are single-comb White Leghorns from pullet matings. The mothers of these birds were selected from trap-nest and egg-weight records covering a period of approximately four months between the time their first eggs were laid and the beginning of the hatching season. Like records of the entire flock of about 160 birds hatched during the season of 1915 have been kept throughout the year, and the selection of breeders for the past season's hatch, with one or two eliminations and a few additions, will hold for another breeding year. In other words, the selections made from records of the first four months of laying have, in this case, proved generally satisfactory. With the exception of 28 birds, the entire flock of the past year's rearing has been carefully pedigreed and the complete poultry record to date amounts to about 35,000 separate entries.

METEOROLOGICAL RECORDS.

During the past fiscal year the substation has assumed the duties of a cooperative observer for the Hawaiian section of the Climatological Service, United States Weather Bureau, daily records of temperature and rainfall having been taken in this capacity since January 1, 1916. As these climatic factors have an important bearing on general crop production, these data are summarized and presented in the following table:

Summary of meteorological records at Glenwood substation from Jan. 1 to June 30, 1916.

Month.	Absolute temperature.		Mean temperature.		Total precipitation.	Number of rainy days.	Number of clear days.
	Maximum.	Minimum.	Maximum.	Minimum.			
	°F.	*°F.*	*°F.*	*°F.*	*Inches.*		
January	79	47	72.60	54.40	19.99	27	2
February	79	46	74.79	53.55	4.73	17	2
March	80	49	72.51	56.64	17.38	24	3
April	77	53	72.42	57.62	18.50	27	2
May	77	53	72.87	58.00	43.47	29	0
June	74	53	71.37	58.87	17.45	30	0
Six months	....	....	72.76	56.51	121.52	154	9

REPORT OF THE TERRITORIAL MARKETING DIVISION.

By A. T. Longley.

During the past year there have been many changes for the better at the division in both organization and equipment, which to a large extent accounts for the heavy increase in the number of consignments handled as well as in the volume of the sales. The division, after three years of effort, is now in a position to give the producers of the Territory much better service than ever before.

The increased appropriation made by the last Territorial legislature and the new building provided for at the same time have been of the greatest assistance to the division in working up the business of the small producer. The facilities for handling all kinds of farm products are now first class, except that a cold-storage plant for the increasing consignments of dressed meats is yet to be installed. The new quarters are located on Mauna Kea Street, just off Queen Street, and contain offices, salesrooms, rooms for candling eggs, fumigating, dressing poultry, and a garage. There were insufficient funds left after the building was completed to provide for a cold-storage plant as originally planned. As a result a great deal of time is now lost and considerable expense to the producer incurred in putting the dressed meats in local private cold-storage plants.

On July 1, 1915, a branch of the division was opened in San Francisco to facilitate the sale of Hawaiian agricultural products on the mainland, particularly pineapples. During the summer of 1915 pineapple canneries were unable, on account of unsettled market conditions, to take all the fruit offered by the small producers, and, as a great deal of it could not be sold locally, the division endeavored to find a market for the fresh fruit on the mainland. In connection with the establishment of the San Francisco branch and the marketing of pineapples the superintendent made a trip to San Francisco and as far east as Chicago. It was found that the report of high prices paid for pineapples in Chicago was erroneous, and that even though fair prices ruled, the Cuban and Isle of Pines fruit could be placed on the Chicago market in better condition and at $1 a crate less than Hawaiian fruit.

The amount of pineapples offered to the division for shipment to the coast during last season was in excess of the number which could be profitably disposed of there and the mistake of accepting too many was made. The shipments during July, 1915, netted about $8 a ton for the fruit in the field, but when the shipments were increased the returns soon became very unsatisfactory, owing in part to the heavy spoilage en route and in part to the glutting of the market by the heavy shipments of the division and also of private parties in the islands. An attempt was made to relieve the congested condition of the market by sending trial carloads to cities as far east as Denver and Kansas City. The heavy spoilage on these shipments, even though the pines were repacked at San Francisco and the spoiled and spotted fruits removed, was such as to result in severe losses on all these shipments. The spoilage was heaviest when the pines were overcrowded on the steamer without adequate provision for ventilation and cooling. During the year a total of 23,532 crates were shipped for which returns have been received. The returns on these were not quite sufficient to cover freight charges, cost of crates, and other marketing expenses.

The quality of produce received by the division is steadily getting better, and shippers are paying more attention to grading and packing. Some producers who are putting up a uniform article are getting higher prices for their products, due to the increased demand for first class island produce. The marketing of eggs had caused a great deal of trouble heretofore, but since the division established three grades—"selects, "firsts," and "seconds"—the marketing of eggs has been much simpler. "Select" eggs must have the name and address of the producer and his guaranty stamped on each egg. There have been more calls for stamped eggs at 3 cents above the market price than the division has been able to supply.

Practically all the island agricultural products have been represented in the individual consignments received by the division, ranging in size from 1 dozen eggs to 30 carcasses of beef. The consignors were of many nationalities.

Up to January, 1916, no expert accountant had ever gone over the bookkeeping system of the division since it was first put under the supervision of the experiment station in 1913, and as the business was outgrowing the old system, an expert accountant was called in to revise the system and balance the books. The new system has been in operation for six months and is proving satisfactory. In accordance with the new plan, the books are audited each quarter by an expert accountant. Beginning with July 1, 1916, a cost-accounting system is planned for all departments of the business.

To facilitate the handling of small sales to consumers a retail vegetable and fruit department and a retail butcher shop were opened on June 1, 1916. The sales from these departments are practically all for cash, and purchasers are required to take their purchases with them. By this arrangement the cost of bookkeeping and delivery is saved the purchaser.

The establishment of these two new departments reduces the consignment bookkeeping a great deal, for the reason that large quantities of produce are charged to these departments by the consignment department, thus doing away with the many small credits that had to be made when retail sales were made direct from consignments. The returns from the retail branch for the month of June have been very satisfactory, and it is expected that these departments will become self-supporting.

In order to get better prices for the producers on the island of Hawaii, especially in the vicinity of Hilo, the Hawaiian board of supervisors is considering a proposition to subsidize a branch of the Territorial marketing division in Hilo. Such a branch would be of great assistance in regulating the supply in Hilo and in shipping any surplus produce to Honolulu.

The sales of the division during the past year have increased considerably over previous years, and the cost of marketing produce has been reduced. The sales for the different branches of the business for the year are as follows:

Local consignments (produce received on consignment and sold locally)	$66, 977. 94
Sales of purchased merchandise (feed, seed, crates, packing material, and produce purchased on the outside to fill orders)	43, 087. 29
Mainland consignments (all shipments sent to the San Francisco branch to be sold for the account of the division)	17, 659. 22
Gross total	127, 724. 45
Less sales from consignment branch to retail branch	6, 638. 67
Net total	121, 085. 78

During the coming year the division plans to get in closer touch with producers and their marketing difficulties by having representatives visit their farms and look into local markets. It is planned to keep a more accurate record of what is being produced and when it will be ready for market.

Up to the end of this fiscal year the superintendent, in addition to supervising the work of the division, also attended to many duties as clerk of the experiment station. Being relieved of the latter duties beginning July 1, 1916, he will devote his entire time to the work of the marketing division.

O